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NEW HISTERIDAE (COLEOPTERA) FROM THE BURROWS OF THE FLORIDA POCKET GOPHER

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Specialized collecting in the burrows and nests of certain animals by Mr. H. G. Hubbard (1894, 1896) and recently by the late Mr. C. C. Goff and Mr. H. K. Wallace has brought to light the remarkable and peculiar associations of arthropods occasionally found in such situations.

The Histeridae thus collected are of particular interest in that in certain cases they have proved to represent distinct genera, the species of which seem to be highly endemic to their particular ecological niches. The genera of the *Saprininae*, *Chelyoxenus* Hubbard (1894) occurring in the burrows of *Gopherus* in South Eastern United States, *Eremosaprinus* Ross[1] (1939) apparently peculiar to burrows of *Dipodomys* in the South West[2] and the genus *Geomysaprinus* herein described collected in the burrows of *Geomys* in Florida, are notable examples.

The above genera although often possessing specialized characters retain primitive features which suggest a great antiquity. The relatively stable environmental conditions which must prevail in these subterranean habitats have perhaps served to shelter these guests from the selective effects of a changing external environment.

[1]The writer now feels that this should be considered a distinct genus rather than a subgenus of *Saprinus* Er. as originally proposed.

[2]Hubbard (1896) mentions several undescribed Histeridae collected in burrows of *Dipodomys* near Palm Springs, California. Mr. R. L. Wenzel, who is studying these specimens which are deposited in the U. S. National Museum, informs me (in litt.) that two of the species represent *Eremosaprinus*.

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The biology of these Histeridae is not known but the fact that larvae and adult members of this family are generally predators suggests that these species prey upon various stages of the other arthropod occupants of the burrows such as those of the coprophagus Scarabaeidae.

The material upon which this paper is based was recently secured by the late Mr. C. C. Goff and Mr. H. K. Wallace of the Florida Experiment Station in the burrows of the Florida Pocket Gopher, *Geomys floridanus floridanus* (Audubon and Bachman) and was kindly sent to me for study by Mr. O. L. Cartwright of the Clemson Agricultural College, South Carolina. Mr. Cartwright informs me that the fauna of these burrows was collected by means of bait traps placed in the burrows the openings of which were sealed to prevent the entrance of insects from the outside. Traps to eliminate the gopher occupant were set simultaneously. He also informs me that Mr. T. H. Hubbell of the University of Florida will publish a generalized account of the fauna of the burrows based largely upon Mr. Goff's work.

The Histeridae with but one exception[3] represent four new species. Two of these require the erection of the following new genus.

Saprininae

Genus **Geomysaprinus** new genus

Oval, robust, convex. *Head* with front not transversely margined; supra-ocular striae present, carinate; surface strongly rugulose throughout; mandibles small, acutely margined. *Pronotum* with sides sinuate, apically convergent; lateral areas of disc longitudinally rugulose; base unmargined. *Elytra* with inner marginal stria of epipleura entire, extending medially along epipleural fold; humeral stria present, entire; disc striate, fourth dorsal stria arched at base, sutural stria entire or obsolete basally; surface very finely punctate. *Pygidium* elongate, convex, deeply margined laterally and apically; surface transversely rugose, imbricate in appearance. *Prosternum* elevated, narrow, surface horizontal, sides vertical; with two separate pairs of striae, an inner pair closely subparallel and an outer sinuate pair terminating apically in small foveae which are united across the apex by a fine stria. *Fore-tibiae* deeply dentate, the apical three dentations largest, each bearing a small tooth; ventral surface rugose. *Tarsal claws* equal, separate, slender, feebly curved, nearly as long as terminal tarsal segment.

---

[3]A female specimen of *Hister abbreviatus* Fab. from Lake Streaty, Polk Co., Florida, collected August 10, 1938, by Mr. C. C. Goff. This species is usually found associated with cow dung and occurs widespread throughout the United States. Its occurrence in these burrows is probably in the role of an accidental visitor.

Genotype: *Geomysaprinus goffi* n. sp.

This genus is allied to *Chelyoxenus* Hubbard from which it can readily be distinguished by the fact that the outer claw of each tarsus is not reduced but is equal in length to the inner claw. The peculiar rugose sculpture of the head, pronotum and pygidia as well as the striation of the elytra and prosternum are additional points of differentiation.

The striation of the prosternum seems to be more generalized than that of *Chelyoxenus* and is quite similar to that of the *pectoralis* group of *Saprinus* which in the author's opinion should be regarded as the generalized type of prosternal striation for the *Saprininae*.

It is of interest to note that all the species of *Saprininae* of our fauna which possess entire humeral elytral striae (a primitive condition) fall in genera, the species of which are apparently confined to the burrows of certain animals: e. g., *Chelyoxenus* Hubbard, *Eremosaprinus* Ross[4] and *Geomysaprinus* n. gen.

The two species of *Geomysaprinus* which are described herein are both from Florida where they seem to be peculiar to burrows of *Geomys*. The writer believes that when such burrows are investigated throughout the range of the genus, particularly in Mexico, more species will be discovered.

Geomysaprinus goffi n. sp.

(Fig. 1)

Male.—(Fig. 1.) Elongate-oval, black, shining. *Head* rugulose throughout, rugulosities distinct, separate, short, irregular in length and position; supra-ocular striae distinct, carinate; a short carinate stria is also present above each antennal socket; mandibles acutely margined, sides rugulose basally. *Pronotum* twice as wide at base as median length, feebly convex; sides sinuate, convergent, curved inward at basal half, arcuate outward in anterior half; frontal emargination shallow; marginal line deep, entire, base unmargined; disc smooth, evenly, sparsely micropunctate; sides strongly longitudinally rugulose; basal margin with a single incomplete row of rather large punctures. *Elytra* slightly broader than long; sparsely, evenly micropunctate throughout, more strongly so in apical half between third dorsal and sutural striae; lateral marginal line fine, terminating at outer apical angle; inner marginal stria of epipleura arcuate, extending medially along the length of the epipleura and across apices of elytra, terminating at suture; a short impressed stria present on inner side in basal fourth; humeral stria present, extending from base and terminating at apical sixth of elytra;

[4]Humeral striae obsolete in at least one species.

oblique humeral fine, indistinct, parallel to first dorsal but slightly shorter; first dorsal stria abbreviated at middle; second dorsal stria somewhat longer than the first; third slightly longer than second; fourth equal in length to first, abruptly arched at base towards suture; sutural stria fine, extending forward from near apex and gradually terminating just within basal half. *Pygidium* elongate, convex, deeply margined except laterally at extreme base; dull, alutaceous, not punctate but instead transversely rugulose, appearance imbricate. *Metasternum* depressed medially with a few coarse median punctures. *Prosternum* elevated, horizontal, narrow but not carinate, sides vertical; inner pair of striae closely parallel at basal half thence gradually convergent towards apex but not uniting, terminating slightly before apex; outer pair of striae converging from base but in anterior third, after closely approaching inner pair, diverge and unite across extreme apex; apical foveae present along outer striae just behind apex. *Fore-tibiae* deeply five-dentate, the three apical dentations largest; upper surface smooth, tarsal groove shallow but distinct; ventral surface transversely rugulose. *Length* 4 mm., *width* 3 mm.

Female.—Similar in all respects to the male with the exception that the metasternum is not punctate nor depressed medially.

Holotype: male (No. 53440 U. S. N. M.) and *allotype* female (No. 53440 U. S. N. M.) collected at Leesburg, Florida, April 15, 1938, in a burrow of *Geomys*, by Mr. C. C. Goff for whom this species is named.

Sixty-nine paratypes from several localities in Florida collected at various dates in 1938 are as follows: Leesburg, March to July, 7 ♂, 15 ♀; Eau Gallie, May and August, 1 ♂, 4 ♀; St. Cloud, August, 2 ♂; Putnam Co., July, 2 ♂; Dug Creek, August, 1 ♀; Newnan's Lake, Alachua Co., June and July, 9 ♂, 8 ♀; Alachua Co., June, 12 ♂, 8 ♀. All of the above were collected by Mr. C. C. Goff excepting those from Alachua Co., which were collected by Mr. H. K. Wallace.

Paratypes will be deposited in each of the following collections: California Academy of Sciences, San Francisco; Snow Museum, University of Kansas; Canadian National Collection, Ottawa; British Museum of Natural History, London; Museum of Comparative Zoology, Harvard University; Philadelphia Academy of Sciences; University of Michigan Collection; Ohio State University Collection; Illinois Natural History Survey Collection; Florida Experiment Station Collection; Florida State Plant Board Collection; O. L. Cartwright; H. C. Fall; C. A. Ballou; R. L. Wenzel and that of the writer.

Geomysaprinus tibialis n. sp.

(Fig. 2)

Male.—Broadly oval, subcircular; elytra and pygidia piceous, legs reddish-brown, pronotum and head black; dull. *Head* shining, strongly rugose, rugosities small, round; supra-ocular and antennal carinae distinct. *Pronotum* not quite twice as wide as long; sides very feebly sinuous, anterior angles abrupt; frontal emargination very shallow; basal margins nearly straight, converging to form a broad obtuse angle; anti-scutellar impression present but indistinct; marginal line entire, absent

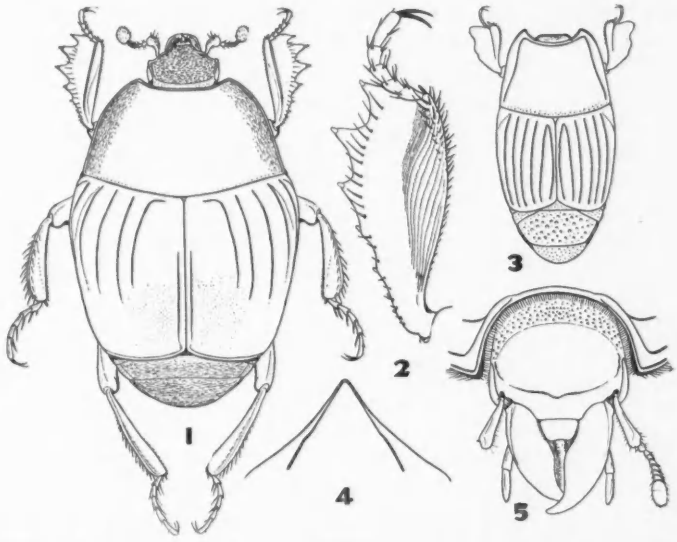

Figure 1. *Geomysaprinus goffi* n. sp., holotype. Figure 2. Left fore-tibia of *Geomysaprinus tibialis* n. sp., holotype. Figure 3. *Atholus minutus* n. sp., holotype. Figure 4. Outlines of prosternal lobe of *Spilodiscus floridanus* n. sp., holotype. Figure 5. Head of *Spilodiscus floridanus* n. sp., holotype (frontal). All figures are by the author.

along basal margins; punctuation fine, indistinct anterio-medially, becoming coarser baso-laterally, somewhat strigose; laterally from base to apex the punctures disappear and are replaced by strong longitudinal rugulosities; basal margin with a row of rather coarse punctures. *Elytra* dull, alutaceous; punctation fine, shallow, sparse throughout but slightly larger in apical half; lateral marginal stria fine, terminating at apical angle; inner marginal stria of epipleura distinct, extending from base medially along epipleural fold, terminating at apical angle; inner humeral stria well impressed, subentire, abbreviated both at base and apex, more so at apex; oblique humeral rather coarse, not parallel

to first dorsal stria and but half as long; first three dorsal striae well-impressed, extending from base but abbreviated apically, the first within the apical fourth, the second and third as well as the fourth just before attaining apical third of elytra; fourth dorsal stria somewhat crenulate, broadly arched basally and joining the base of the sutural stria which is entire; area adjacent to suture in the basal half shining and somewhat depressed. *Pygidium* elongate, not strongly convex; deeply margined except laterally in basal third; surface dull, alutaceous, not strongly but distinctly, transversely, evenly rugulose, appearance imbricate. *Metasternum* evenly, finely punctate and alutaceous throughout; not depressed medially. *Prosternum* elevated, horizontal, narrow, sides vertical; inner pair of striae convergent from base, subparallel medially thence convergent but separate to apex; outer pair of striae convergent from base but medially become parallel with inner pair, terminating apically in small indistinct foveae, fine transverse apical line indistinct. *Fore-tibiae* (fig. 2) broadly arcuate on both inner and outer margins; outer margin with three large dentations; upper two dentations obsolete; tarsal groove obsolete, replaced by oblique rows of fine, crenulate striae; ventral surface transversely rugulose. *Length* 3 mm., *width* 2.75 mm.

Holotype male (No. 53441 U. S. N. M.) collected at Eau Gallie, Florida, May 1, 1938, by Mr. C. C. Goff in a burrow of *Geomys*.

Two male paratypes are designated; one with the same data as the holotype and the other was collected at Lake Streaty, Polk Co., Florida, August 10, 1938, by Mr. C. C. Goff. They will be deposited in the collection of the Florida Experiment Station and that of the writer.

In addition there are at hand two female specimens which the writer feels certain represent this species, but because of the striking, apparently secondary sexual, differences in their fore-tibiae and the fact that they were not collected with the males, they are not designated paratypes. They were secured at Leesburg, Florida, August 15, 1938, by Mr. C. C. Goff.

The fore-tibiae of these females are very similar to those present in both sexes of *goffi* as illustrated (fig. 1). The inner margin is nearly straight and the tarsal groove is distinct and deep.

Tibialis can be readily separated from *goffi* by its much smaller size, broad circular form and the entire sutural striae of the elytra; the males may be separated by the protibial differences outlined above.

Histerinae

Tribe Histerini

Spilodiscus floridanus n. sp.[5]

(Figs. 4 and 5)

Male.—Large, robust; entirely black, shining. *Head* (fig. 5) large, broad, impunctate; frontal stria broadly arcuate, very weakly impressed and indistinct except above eyes; clypeus and labrum impunctate; mandibles large, unmargined, impunctate except basally on outer sides. *Pronotum* broad, impunctate; fine marginal line extending from basal angles along sides and terminating behind eyes, there turning caudad and nearly uniting with the anterior transverse portion of the outer striae which commence as series of punctures along basal margin and extend entire and strong forward and around apical angles thence transverse across apical emargination, abruptly sinuate forward at a point behind eyes; inner lateral stria nearly entire, parallel with outer lateral stria, abbreviated apically (hooked inward and joining outer lateral in paratypes); interstrial areas unsculptured; epipleurae rather densely fimbriate, hairs short, stiff, brownish in color. *Elytra* entirely black, impunctate; epipleural fold deeply tristriate; humeral stria obsolete; oblique humeral distinct, fine, present in basal third; disc with but two entire impressed, impunctate striae, third dorsal stria distinctly represented at base only, apically by but indefinite rudiments; other dorsal striae obsolete except the sutural which is faintly represented in apical half. *Propygidium* faintly alutaceous; punctures irregular, coarse. *Pygidium* strongly convex; evenly and very densely punctate, punctures large, round, deep. *Prosternum* with lobe (fig. 4) very acute, sides emarginate; marginal stria strong, entire. *Fore-tibiae* deeply bidentate, other dentations absent; apical denticule single. *Length* (excluding head and pygidia) 6 mm., *width* (at humeri) 5.5 mm.

Holotype male (No. 53442 U. S. N. M.) and three paratypes, two males and one female, collected at Leesburg, Florida, April 15, 1938, by Mr. C. C. Goff. An additional paratype, a male, from Alachua Co., Florida, collected June 28, 1938, by Mr. H. K. Wallace, is also designated.

Paratypes will be deposited in the collection of the Florida Experiment Station, Mr. O. L. Cartwright and that of the writer.

In spite of the absence of red elytral maculation[6], this species

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[5]This category, in the author's opinion, should be regarded as a distinct genus rather than as a subgenus of *Hister*. It should be limited to include only the species which possess strongly bidentate fore-tibiae and fimbriate pronotal epipleurae, thus excluding the species of the "*militaris* section."

[6]There is absolutely no indication that the prevailing uniform black color is due to the exudation of grease which often partially obscures the usual red elytral maculation characteristic of the majority of the species of this genus.

is unquestionably, by its external as well as genitalic characters, a *Spilodiscus*. The acute prosternal lobe and the uniform black color ally it with *gloveri* (Horn) (1870) which is known to me only from the original citation which places its distribution as "Fort Cobb, Indian Territory" (Oklahoma).

At my request, Mr. Mark Robinson of Philadelphia very kindly compared a specimen of *floridanus* with the type of *gloveri*. His comparison verified its close relationship with *gloveri* and indicated the following points of di erentiation between the two species: *floridanus* has greater dimensions; its basal pronotal punctuation is more pronounced; the third dorsal elytral striae are obsolete apically rather than entire to the apex, the sutural striae of the elytra do not extend as far basally, its pygidia are more coarsely and densely punctate and the sides of the acute prosternal lobe are more deeply emarginate than in the case of *gloveri*.

The fact that so large a beetle should have escaped the efforts of collectors until recently indicates that this species is perhaps limited in occurrence to the burrows of *Geomys* which seem to have been long uninvestigated. It is thus conceivable that its near relative, *gloveri*, which apparently has not been collected since the type specimen was secured, is also limited to certain animal burrows and thus may not have been retaken in all these years.

Atholus minutus n. sp.[7]

(Fig. 3)

Female.—Small, elongate, not strongly convex; sides of pronotum, elytra and pygidia broadly, continuously arcuate; color dark ferrugineous. *Head* with front flat, slightly concave; surface minutely, transversely strigose, minutely and indistinctly punctate; transverse frontal margin entire, straight, strongly carinate; clypeus flat, depressed, minutely punctate; mandibles small, concave, margins strongly carinate. *Pronotum* as long as broad; sides, except apical angles which are abruptly rounded, straight, not strongly convergent; anterior emargination deep; basal margin broadly arcuate; fine marginal line entire except medially along anterior emargination; no trace of outer lateral striae; inner lateral striae deeply impressed, sinuate, extending forward from just before base of pronotum well into apical angles thence along frontal emargination; entire discal surface between inner lateral striae sparsely, minutely punctate except for a double row of coarser punctures along basal margin. *Elytra* but one-fourth longer than pronotal length; impunctate; epipleura tristriate; humeral stria obsolete; oblique

[7]The writer believes that this should be regarded as a distinct genus rather than as a subgenus of *Hister*.

humeral stria fine, present in basal third; all discal striae present, entire, deeply impressed, indistinctly punctate; fifth and sutural striae definitely united basally. *Propygidium* faintly alutaceous; punctures large, coarse, some crescent-shaped; interspaces irregular, at least as wide as punctures, micro-punctate. *Pygidium* strongly convex; with smaller, round, evenly-spaced punctures present except at apex; interspaces smaller, scarcely alutaceous, micro-punctate. *Mesosternum* almost truncate, only very slightly emarginate. *Prosternum* not striate; lobe acute, marginal line entire. *Fore-tibiae* reddish-brown; very broadly tridentate, upper dentation small, terminal dentation large, broad, mono-denticulate, all dentations rounded. *Length* (anterior pronotal margin to sutural apex) 2.25 mm., *width* (at humeri) 2 mm.

Holotype female (No. 53443 U. S. N. M.) collected at Leesburg, Florida, April 15, 1938, by Mr. C. C. Goff in a burrow of *Geomys*.

The very small size and narrow outline of this species distinguish it at once from all other *Atholus* of this fauna. It is not related to *tornatus* (Lec.) (1880) as may be indicated by its narrow form. According to Mr. R. L. Wenzel (in litt.), *tornatus* is "nearly stoutly cylindrical in form and with only the outer (elytral) striae well impressed, the rest being complete but so finely impressed as to be nearly invisible. In addition it has an outer lateral pronotal stria, this abbreviated behind."

ACKNOWLEDGMENTS

I wish to express my thanks to Mr. O. L. Cartwright for sending me this very interesting material for study, to Mr. Mark Robinson for the type comparison and to Mr. R. L. Wenzel, Dr. E. G. Linsley and others for valuable suggestions and aid.

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A BLIND CRICKET-LOCUST (TYPHLOCEUTHOPHILUS FLORIDANUS n. gen. et sp.) INHABITING GEOMYS BURROWS IN PENINSULAR FLORIDA

(Orthoptera, Gryllacrididae, Rhaphidophorinae)[1]

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The remarkable insect here described, which was discovered in 1938 by the late C. C. Goff,[2] is a member of the peculiar assemblage of arthropods commensal in the burrows of Florida pocket-gophers (*Geomys floridanus* subspp.). It is the first completely blind Rhaphidophorid to be made known, and is evidently highly adapted to its hypogeic commensal existence.

Typhloceuthophilus new genus[3]

Small Ceuthophilini, with the general structure and facies of *Ceuthophilus* of the subgenus *Geotettix*,[4] and doubtless derived from that stock, but distinguished by being blind (with mere pigmentless traces of eyes), by the sensory area of the maxillary palpi being apical instead of continued proximad along the ventral surface of the distal segment, by having 3-segmented tarsi on all legs (other genera of the tribe with at least the middle tarsi 4-segmented), by the reduced tibial armature of spurs, by the separated openings of the spermathecal ducts and the correspondingly and uniquely modified spermatophore, and by the distally roughened surface and margins of the ovipositor.

In greater detail the genus is characterized as follows: Resembling *Geotettix* except as indicated above. Fastigium verticis low, bluntly conical, weakly compressed, not sulcate. Elevated admesal margins of antennal fossae subcontiguous. Sensory membranous area of fifth (terminal) segment of maxillary palpus apical, slightly oblique and extending very briefly onto ventral surface of segment as a V-shaped area. Thoracic nota all ventrally marginate. Outer margin of cephalic coxae bluntly obtuse-angulate or briefly subacuminate at apex of angle. Cephalic and middle legs slender; cephalic femur just perceptibly

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[1]Contribution from the Department of Biology of the University of Florida and the Museum of Zoölogy of the University of Michigan.

[2]See Hubbell and Goff—Florida Pocket-gopher Burrows and their Arthropod Inhabitants. *Proc. Florida Acad. Sci.*, vol. 4, 1939 (1940). This paper discusses the occurrence and habitat distribution of *Geomys* in Florida, the characteristics of the burrows, the arthropods inhabiting the burrows, and methods of collecting and studying the commensal species.

[3]From Τυφλος=blind, and *Ceuthophilus*, the most closely related genus.

[4]See Hubbell, T. H.—A Monographic Revision of the genus *Ceuthophilus*. *Univ. Florida Publ., Biol. Sci. Ser.*, vol. II, No. 1, 1936, p. 406.

heavier than middle femur, unarmed above; middle femur with small caudogenicular spur as in *Ceuthophilus*. Caudal femora relatively short and but little expanded proximad, dorsal and ventral margins subparallel in proximal half, tapering gently to genicular region in distal half, ventral carinae multidenticulate, both genicular lobes minutely spined near apex. Caudal tibiae armed as in *Ceuthophilus*, except for the absence of one (or occasionally of both) of the paired ventro-distal spurs homologous with the calcars. All tarsi 3-segmented, the elongate proximal segment formed by fusion of metatarsus and true second segment,[5] position of apex of metatarsal component of caudal tarsus occasionally marked by a small mediodorsal spine or rarely by a pair of such spines (see figure of allotype, Pl. I, fig. 9) at about distal fourth of the compound proximal segment; the two proximal segments compressed, ventrally carinate and ventrodistally sharply acuminate, their ventral carinae furnished with a row of bristly setae along their full length (cf. the *type B* tarsus found in some members of *Geotettix*); distal segment of tarsus less compressed and ventral setae finer; claws extremely elongate and slenderly aciculate, gently curved, lacking a proximal sensory seta. Mesosternal foramen transverse; metasternal foramen small, slightly transverse, semicircular or crescentic in outline, its "middle piece" distinctly set off by grooves and narrow, with its sides anteriorly convergent to the narrowly rounded cephalic end.

Cerci in both sexes simple, rather short, evenly tapering to the acuminate apex. Male subgenital plate of *Geotettix* type, its halves separated by a weakly impressed median sulcus,[6] styles absent, general form similar to that of *Ceuthophilus alpinus* (cf. Hubbell, *op. cit.*, Pl. XXV, figs. 782–3). Spermathecal ducts of female opening separately on sides of spermathecal papilla, instead of in a median invagination. Spermatophore bicornuate. Ovipositor similar to that of species of *Geotettix* except for the following characteristics, which are unique: distal half of each dorsal valve with its surface somewhat shagreenous and sparsely minute-setose, dorsal and ventral margins and obliquely truncate apex with edges very minutely roughened, the outline under moderate magnification being minutely jagged or irregularly crenulate; distal portions of ventral valves with surfaces and margins similarly minutely roughened or nodulose, the irregularities of the surface extending onto the bases of the five strong distal teeth (including the apical hook as one); teeth narrowly acuminate, rather straight and all directed

[5] As in early instars of *Ceuthophilus*, and as in the cephalic and caudal tarsi of adults of *Daihinia* and *Ammobaenetes*. For discussion of the significance of this neotenic characteristic, see Hubbell, *op. cit.*, pp. 502–3.

[6] In my key to the males of *Ceuthophilus* (Hubbell, *op. cit.*, p. 39), the primary division between *Ceuthophilus* s. s. on the one hand and *Geotettix* and *Hemiudeopsylla* on the other was based, for want of a better character, on the presence in the former of a deep percurrent median sulcus separating the halves of the subgenital plate, and on the absence of such a sulcus in the two latter groups. The distinction is a real one, but difficulty may be experienced in applying it for two reasons—first, that in species of the Fusiformis, Silvestris, Alpinus, Californianus and Latipes Groups a shallow sulcus extends proximad from the base of the meso-distal notch, and second, that in dried material the subgenital plate often contracts so as to make this sulcus appear deeper and more percurrent than is normal. Consideration of the associated characters will usually enable one to recognize the occurrence of such distortion.

more or less caudad (instead of the two proximal teeth being vertical or somewhat retrorse, as in *Ceuthophilus*); proximal portions of ventral valves weakly sclerotized, their ventromesal surfaces membranous.

Genotype and only included species: *Typhloceuthophilus floridanus* n. sp.

Typhloceuthophilus floridanus new species

(Plate I and text figures 1 to 5)

1940. *Typhloceuthophilus floridanus* Hubbell MS, in: Hubbell and Goff, Proc. Florida Acad. Sci., vol. 4, 1939.

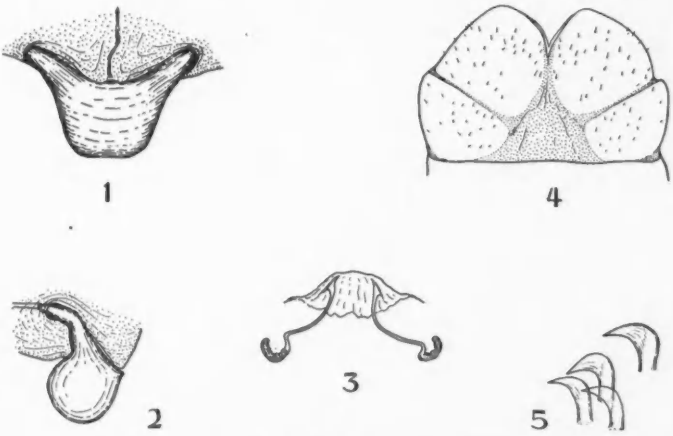
Holotype: Male, Leesburg, Lake Co., Florida, March 29, 1938, taken by C. C. Goff in burrow of *Geomys floridanus* subsp.; *allotype* a female with the same data, both in the Museum of Zoölogy, University of Michigan.

Description of holotypic male.—Coloration uniformly pale straw-color, without noticeable markings, except caudal margins of thoracic and abdominal nota slightly darkened; surface nearly glabrous, except legs finely setose. Body length, exclusive of cerci, 10.4 mm.[7]

Head: Suboval in cephalic aspect, more pointed below, 2.3 mm. broad, 3.1 mm. tall from top of vertex to ventral border of clypeus; region of eyes altogether without pigment, position of eyes indicated by a pair of low, inconspicuous subcrescentic or narrowly arcuate convex ridges bordering dorso-lateral margins of antennal fossae; antennae slender, evenly tapering, rather short, length approximately 15 mm.; maxillary palpi moderately elongate (4.0 mm.), slender, proximal two segments short, length of 3rd segment 1.1 mm., of 4th segment .8 mm., of 5th (terminal) segment 1.4 mm., apical sensory area of last slightly oblique, but not extending proximad on ventral surface as in *Ceuthophilus*. *Thorax:* Apterous. Pronotum in lateral aspect slightly longer than high, ventral margins of lateral lobes straight and nearly parallel to dorsum, ventro-caudal angle abruptly and ventro-cephalic angle more broadly rounded, cephalic and caudal margins nearly truncate; ventral margins of meso- and metanotum broadly rounded, caudal margin of mesonotum weakly produced mesad, of metanotum truncate. *Legs:* Cephalic and middle legs slender, subequal, appearing relatively elongate. Cephalic femur 1.36 (1.29–1.50, mean 1.37, st. dev. .047) times length of pronotum; ventro-cephalic carina with 3–3 short spurs in distal 3/5, ventro-caudal carina unarmed on right leg, with a single minute spurlet on left leg. Cephalic tibia unarmed and weakly sulcate above, beneath with a pair of opposite spurs at distal 3/5 and another pair beneath apex, these spurs less than or subequal in length to tibial depth. Cephalic tarsus with two proximal segments compressed, their

[7]All measurements and descriptions in this paper are based on alcoholic material. After the types were described, measured and figured they were treated with xylol and mounted dry on pins. The conventions used herein are the same as those in the revision of *Ceuthophilus* cited in footnote 4.

ventral carinae set with row of stiff, bristly setae, their ventro-distal apices acuminate; distal segment less compressed, expanding slightly distad, its weak ventral keel with minute slender setae; claws extraordinarily elongate and aciculate, gently curved, equal in length to distal tarsal segment. Middle femur armed with short genicular spur on caudal face; ventro-cephalic carina with 5–3, ventro-caudal with 2–2 short spurs. Dorsal surface of middle tibia weakly sulcate, with pair of short spurs at proximal third (variable in series), and ventral surface with one short spur at distal 3/5 (variable in series) in addition to ventro-distal pair. Middle tarsus as in cephalic leg. Caudal femur grylloid, 2.61 (2.36–2.79, mean 2.54, st. dev. .12) times length of pronotum,



Typhloceuthophilus floridanus

Text Fig. 1.—Spermatophore perched on spermathecal papilla in roof of genital chamber of female, in caudal aspect, showing spermatophore ducts inserted in paired openings of spermathecal ducts; greatly enlarged. 2.—Same as last, viewed from left side. 3.—Spermathecal papilla and paired spermathecae of female, ventral view after removal of tissues; much enlarged. 4.—Subgenital plate of male, ventral view of flattened slide mount, x 20. 5.—Group of the most specialized penial setae from near center of setose area of ventral lobe of penis; greatly enlarged.

All figures drawn under binocular microscope from specimens taken at Leesburg, Florida, and preserved in alcohol.

1.92 (1.76–1.97, mean 1.85, st. dev. .045) times length of cephalic femur, 4.05 (3.58–4.35, mean 3.94, st. dev. .19) times as long as maximum breadth; ventro-cephalic carina with 35–34 small crowded denticulations, ventro-caudal with 34–32 similar ones, both genicular lobes of each femur minutely unispinose, dorsal and lateral faces almost without denticulations (2 minute ones on left leg). Caudal tibia 1.19 (1.08–1.23, mean 1.16, st. dev. .03) times length of caudal femur, armed above with spurs and spinose denticles as in *Ceuthophilus*; spine formula of outer carina (right) 7/8/7/7/11, (left) 7/7/7/6/10; spurs slender, very weakly

curved, dorsal surface with a pair of very delicate carinulae extending nearly to base of spur, apex abruptly but very minutely inbent, surface of spur glabrous except for a few short scattered setae; spurs moderately elongate, length of subdistal spur of cephalic carina 1.1 mm. (slightly less than twice tibial depth opposite its base), spur bases separated from each other and from ends of tibia by intervals distinctly longer than the spurs, these intervals, measured from base to apex on outer carina, 2.1/1.4/1.2/1.4/2.1 mm.; distal pair of spurs rather short (cephalic .60, caudal .66 mm.), adjacent to the elongate dorsal calcars (cephalic 1.44, caudal 1.56 mm.); ventral calcars more than half as long as dorsal (cephalic .9, caudal 1.02 mm.); ventral surface of tibia unarmed except at apex, where there is on each leg a single minute spur (often absent in series) which represents the outer member of the pair (homologous with a third pair of calcars) usually present in Ceuthophilini. Caudal tarsus as described in generic diagnosis and figured in Plate I, fig. 6. Abdominal tergites unspecialized, dorsum rounded, becoming weakly tectate caudad.

Terminal abdominal structures: Caudal margins of first seven segments truncate, of eighth weakly produced mesad, broadly rounded-obtuseangulate, exposing ninth; latter slightly more strongly produced, its apex briefly membranous and very minutely setose. Epiproct subtriangular, its surface divided into an apical and a pair of proximo-lateral pale, tumid membranous areas by a depressed, sclerotized brownish mesal plate; this plate diamond-shaped except that its lateral angles are prolonged and bent gently cauded to reach the sides of the epiproct, its meso-distal point extending between the broad, short arms of the distal membranous area, and its meso-proximal point sending a narrow prolongation to base of epiproct, thus barely separating the tumid latero-proximal membranous areas; suranale membranous, declivent, scarcely demarcate from epiproct and with it making a rather sharp apex. Paraprocts membranous except for narrow ventral sclerotized bar, their dorsal margins slightly tumid and gently arcuate. Subgenital plate (text fig. 4) rather short and broad, as a whole somewhat scoop-shaped, apex narrower than base and shallowly emarginate between the broadly rounded submembranous apices of the lateral lobes; the latter not separated by a deep sulcus, but contiguous just proximad of apical notch and thence separated proximad by a widening triangular membranous area; basal plates of lateral lobes plainly set off by membranous grooves which reach the proximo-mesal membranous area, these plates relatively large, constituting about 2/5 of total area of lateral lobes, and sub-triangular with gently convex lateral margins. Pseudosternite a broad, low arch flattened in a vertical plane, with dorsal rim laminately expanded in same plane to form an erect, broadly triangular process with subacute (to parabolically rounded) apex; cephalic lobe narrowly parabolic in outline, small, weakly sclerotized, concealed behind dorsal process of arch. Penial setae (text fig. 5) forming a small rounded patch on surface of ventral lobe of penis, the setae relatively few (approximately 293 in one paratype) and compactly grouped, but setal bases separated by one or two times the diameter of the shafts; outer setae short, moderately stout and nearly straight; inner and most

specialized setae forming short, broad, strongly bent hooks, in edge-view somewhat compressed and narrowing evenly from conical bases to laminate tips, in side view much broader, and bent at about half their length in a strong but variably abrupt curve to slightly more or less than a right angle, the breadth from base to just beyond the point of maximum curvature nearly constant (about 1/4 to 1/5 the length), thence tapering to the very acute apex.

Description of allotypic female: Agrees with male except as follows: Slightly larger, a little more robust, legs relatively shorter. Cephalic femur 1.29 (1.23–1.47, mean 1.34, st. dev. .057) times as long as pronotum, armed on ventro-cephalic carina with 4 small spurs, of which the proximal 3 (right) and 2 (left) are minute; ventro-cephalic carina of middle femur with 5–4 small spurs increasing in length distad, ventro-caudal carina with 3–3 small spurs; dorsal surface of middle tibia with pairs of short spurs at proximal and at distal thirds (right), with an unpaired cephalic spur at proximal third and paired spurs at distal third (left). *Caudal femur* 2.48 (2.23–2.59, mean 2.45, st. dev. .074) times length of pronotum, 1.92 (1.70–1.94, mean 1.82, st. dev. .046) times length of cephalic femur, 3.85 (3.58–4.23, mean 3.95, st. dev. .13) times as long as maximum breadth, ventro-cephalic carina with 35–34 minute denticulations, ventro-caudal carina with 33–35 similar ones, dorsal and inner surfaces not denticulate. *Caudal tibia* 1.14 (1.09–1.24, mean 1.17, st. dev. .039) times as long as caudal femur, spine formula of outer carina 7/8/5/7/9 (right), 7/6/7/8/11 (left); both *caudal metatarsi* armed above with a pair of small, stout-conical denticles at a point slightly distad of the apical fourth. *Ovipositor* straight, 1.55 (1.45–1.89, mean 1.64, st. dev. .088) times as long as pronotum (length of ventral valvulae), modified as described in generic diagnosis; inner valves extending about 3/5 of distance to apex. *Subgenital plate* transverse, with caudal margin very weakly emarginate on either side of the broadly obtuse-angulate apex. *Spermathecal papilla* on dorsal wall of genital chamber fleshy, not sclerotized, rather large and prominent, with sub-oval, slightly flattened top and somewhat undercut lateral margins; *spermathecae* (text fig. 3) paired, with slightly expanded apices and short stalks attached to sides of papillar mass; apparently unique in the family Gryllacrididae[8] in that the slender, tubular ducts open independently in two slit-like invaginations on the sides of the papilla instead of in a median invagination.

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[8]See Ander, K.—Vergleichend-anatomische und phylogenetische Studien über die Ensifera (Saltatoria). *Opuscula Entomologica*, Supp. II, Lund, 1939, pp. 156–164. According to my own observations, in *Ceuthophilus* (*latens*, *gracilipes*), *Styracosceles* (*neomexicanus*) and allied genera the stalks of the paired spermathecae are attached to the sides of the papillar mass, but within this mass the ducts converge and open close together into a common median invagination at the apex of the papilla. *Hadenoecus* has an unpaired median spermatheca with short stalk. In *Pristoceuthophilus* a median unpaired spermatheca has apparently been transformed into a deep, pouch-like prolongation extending in from the dorsal wall of the genital chamber, with its walls wrinkled and membranous except for an area of specialized integument near the inner end; the spermatophores are inserted bodily into this enlarged spermathecal pouch by the remarkably elongate penis of the male.

TABLE I

MEASUREMENTS IN MILLIMETERS

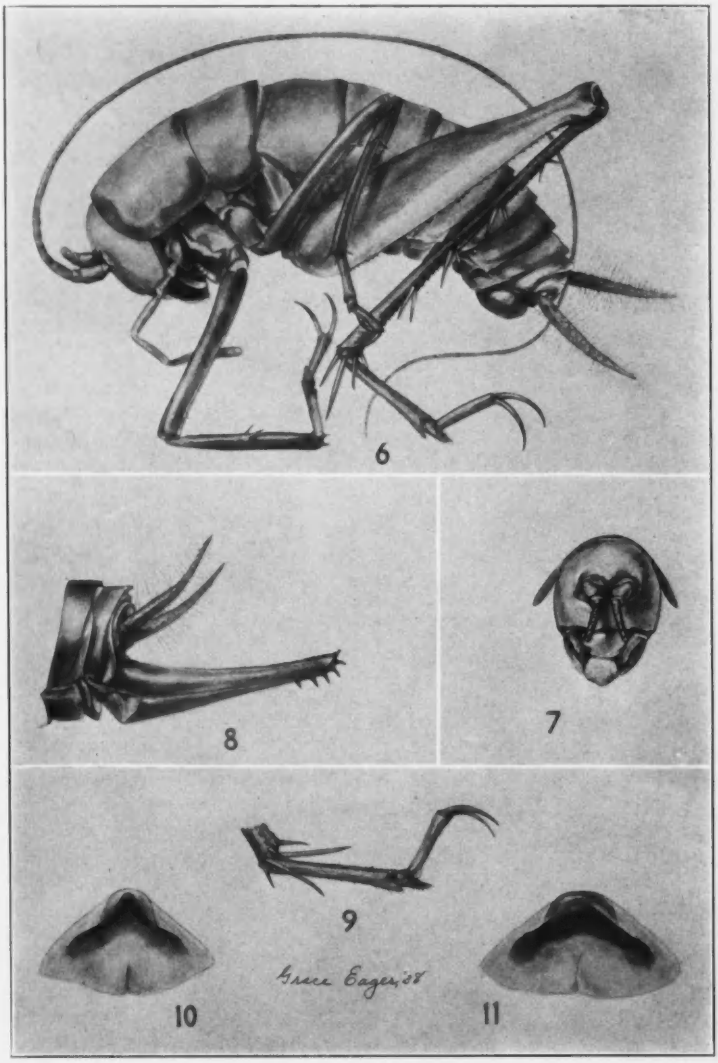
	Length Pronotum	Length Ceph. Femur	Length Caud. Femur	Breadth Caud. Femur	Length Caud. Tibia	Length Ovipositor
MALES						
Holotype	2.8	3.8	7.3	1.8	8.7	
Paratopotype	3.6*	5.0*	8.8*	2.2	10.4*	
Paratopotype	2.3**	3.3**	6.2**	1.5**	7.4	
St. Cloud, Fla.	3.1	4.0	7.3	2.0	8.6	
St. Cloud, Fla.	2.9	3.9	7.4	1.7	8.2	
Eau Gallie, Fla.	3.0	4.1	7.4	1.9	9.1	
Eau Gallie, Fla.	2.7	3.8	6.9	1.6	8.1	
Gainesville, Fla.	2.9	4.1	7.1	1.9	8.7	
Mean of 58 males	2.85	3.91	7.23	1.84	8.37	
Standard deviation	.40	.39	.62	.22	.70	
FEMALES						
Allotype	3.1	4.0	7.7	2.0	8.8	4.8
Paratopotype	3.7*	5.0*	8.8*	2.3*	10.0	5.7*
Paratopotype	2.6**	3.3**	5.9**	1.6**	7.3**	4.1**
St. Cloud, Fla.	3.5	4.3	7.8	2.0	9.3	5.2
Eau Gallie, Fla.	2.8	4.1	7.2	1.7	9.5	4.8
Newnan's Lake, Fla.	3.3	4.6	8.7	2.2	9.5	5.0
Mean of 54 females	3.05	4.10	7.47	1.89	8.73	4.98
Standard deviation	.23	.31	.54	.17	.50	.35

*indicates maximum, **minimum measurements in the entire series studied; other extremes are: maximum breadth of caudal femur, males, 2.3; minimum length caudal tibia, males, 7.2; maximum length of caudal tibia, females, 10.4.

Coloration: In life a nearly uniform cream-color, straw-color or pale yellowish brown, without contrasted pattern, though presenting a faintly annular appearance on account of the darker aspect of the overlapping portions of the thoracic nota and abdominal tergites. The articular points (particularly the condylar articulations of the mandibles) are brownish or black, and the membranous portions of the epiproct, paraprocts and male subgenital plate are lighter than the general coloration. After several months of adult life individuals sometimes develop a darker brownish coloration toward the apices of the femora, on the bases of the tibiae, and on the tarsi.

DESCRIPTION OF PLATE I

Fig. 6.—Holotypic male, Leesburg, Florida, lateral view. 7.—Same as last, cephalic view of head, showing absence of pigmentation in ocular area. 8.—Allotypic female, Leesburg, Florida, lateral view of terminal abdominal segments and ovipositor. 9.—Same as last, caudal tarsus, showing spinose process marking point of fusion of two proximal tarsal segments to form the compound "metatarsus." 10.—Pseudosternite or epiphallus of paratypic male, Leesburg, Florida. 11.—Pseudosternite or epiphallus of paratypic male, Eau Gallie, Florida, showing the broadened arch characteristic of material from the extreme ends of the range.



Typhloceuthophilus floridanus n. gen. et sp.

Individual variation: Differences in individual features of size and body proportions have been noted in the above descriptions. As in other Ceuthophilini the details of the leg armature show much individual variation, in spite of which additional evidence of the generic distinctness of *Typhloceuthophilus* from *Ceuthophilus* is indicated by the starred items in the following tabular comparison:

Typhloceuthophilus	**Ceuthophilus**
Cephalic femur dorsally unarmed.	*Cephalic femur* dorsally unarmed.
Ventrocephalic carina with 1 to 6 (usually 2 to 6) spurs.	Ventrocephalic carina usually with 1 to 4 spurs, occasionally more, rarely unarmed or nodulose.
Ventrocaudal carina with 0 (normally) to 5 small spurs.	Ventrocaudal carina with 0 (in most species) to numerous small spurs.
Cephalic tibia unarmed above except for paired spurs at distal end.	*Cephalic tibia* unarmed above except for paired spurs at distal end.
*Ventral surface almost always with *one pair* of short spurs proximad of distal pair.	*Ventral surface almost always with *three pairs* of short spurs proximad of distal pair.
Middle femur with genicular spur on caudal face.	*Middle femur* with genicular spur on caudal face.
Ventrocephalic carina with 1 to 9 (usually 3 to 6) small spurs.	Ventrocephalic carina with 0 to (rarely) 23 small spurs or denticles.
Ventrocaudal carina with 1 to 7 (usually 2 to 4) small spurs.	Ventrocaudal carina with 0 to (rarely) 22 small spurs or denticles.
Middle tibia normally lacking one or more of the dorsal spurs that are usually present proximad of the apical pair in *Ceuthophilus*.	*Middle tibia* normally with two pairs of dorsal spurs proximad of the apical pair, this somewhat variable, the number normally more or less reduced in some species of *Geotettix*.
Caudal femur	*Caudal femur*
Ventral carinae with numerous (19 to 48, usually 25 to 40) small closely-spaced denticles.	Ventral carinae variably armed, in subgenus *Geotettix* normally as described for *Typhloceuthophilus*.
Both genicular lobes normally minutely unidenticulate (rarely bidenticulate).	Genicular lobes usually unarmed or only caudal lobe denticulate, in a few species both lobes unidenticulate.
Caudal tibia with dorsal armature as in *Geotettix*.	*Caudal tibia* with dorsal armature various, in subgenus *Geotettix* essentially as in *Typhloceuthophilus*.
*Ventrodistal spurs *absent* in about one-third of all individuals, in remainder a *single minute spur* present on one or both legs (paired spurs probably occurring very rarely).	*Ventrodistal spurs almost invariably *present and paired*, except in very rare individual instances.
Ventral surface of tibia unarmed proximad of apex.	Ventral surface of tibia usually with one, two or occasionally several small unpaired spurs proximad of distal pair, in some species these normally or by variation absent.
**Caudal metatarsus* a compound segment, usually unarmed above though often with a slight irregularity in profile at distal fourth, in a small proportion of individuals armed at this point with one (rarely two) small but variably developed spinose denticles.	**Caudal metatarsus* a simple segment, never armed on dorsal surface.

Geographic Variation: The only feature in which any geographic variation may possibly have been noted is the pseudosternite of the male. In the large series from the vicinity of Leesburg the dorsal flange of this sclerite, though slightly variable, has a subacute or narrowly rounded mesal point bordered by gently concave-convergent margins (Pl. I, fg. 10); the two males from St. Cloud possess pseudosternites of the same form. It is surprising to find that the two males from Eau Gallie and the pair from Alachua County (at opposite extremes of the known range of the species) agree in having the arch wider, with the flange broader and its apex less prominent and more broadly rounded (Pl. I, fg. 11) than in the Leesburg and St. Cloud material. The significance of this observation cannot be determined until series from various parts of the range are available for study.

Specimens here recorded:[9] 369—56 ♂, 57 ♀ (holotype, allotype and paratypes), and 257 juvenile specimens, all from Florida and all taken during 1938 (unless otherwise noted) in burrows of *Geomys floridanus* subsp., as follows:

Putnam County: Melrose, Aug. 2, 1939, 1 juv. ♂ (B. A. Barrington).

Alachua County: Gainesville, June 28, 1 large juv. ♀; July 6, 1 ♂; 1 mile west of Newnan's Lake, June 20–July 6, 1 ♀, 26 small to large juv.; near Devil's Millhopper, 7 miles northwest of Gainesville, July 6, 12 juv., mostly small, a few medium-sized (all the above taken by H. K. Wallace); Newnan's Lake, Dec. 3, 1939, 1 ♂ (B. A. Barrington).

Lake County: Leesburg and vicinity, March 21, 1 ♂, 1 ♀, 2 large juv.; March 28–31, 9 ♂, 21 ♀ (including *holotype* and *allotype*), 19 small to large juv.; April 1, 2 ♀, 11 small to large juv.; April 15, 17 ♂, 13 ♀, 34 juv. (of which 24 are first to about 3rd instar, the rest medium-sized to large); April 19–22, 19 ♂, 12 ♀, 32 small to large juv. (some in penultimate instar); May 8, 1 ♂, 2 ♀, 4 small to large juv.; June 11, 1 ♀; June 20–30, 2 ♂, 1 ♀, 69 small to large juv.; July 7, 13 small to medium-sized juv.; Tavares, Feb. 12, 1 large male juv. (all the above taken by C. C. Goff).

Pasco County: Dade City, April 9, 1 medium-sized juv. male (T. H. Hubbell).

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[9]Not including nearly one hundred additional individuals kept alive or reared in artificial observation burrows or watched in the field, and not preserved as specimens.

Osceola County: St. Cloud, Aug. 6, 3 ♂, 1 ♀, 8 small to large juv. (Hubbell, Goff, J. J. Friauf).

Brevard County: Eau Gallie, May 1, 2 ♂, 1 ♀, 5 small to large juv. (C. C. Goff); Aug. 7–9, 18 small to (mostly) large juv. (Hubbell, Goff, J. J. Friauf).

Holotype, allotype and most of *paratypes* and immature specimens in the Museum of Zoölogy, University of Michigan; additional paratypes in the U. S. National Museum, Academy of Natural Sciences of Philadelphia, and Agricultural Experiment Station of the University of Florida. Holotype, allotype and some of paratypes treated with xylol and pinned, remaining specimens in alcohol.

HABITAT

In northern peninsular Florida *Typhloceuthophilus floridanus* has been found in *Geomys* burrows wherever they have been adequately investigated, but never in any other situation. Furthermore, certain aspects of the behavior of this insect evince a high degree of adaptation to commensal life with pocket-gophers. It appears highly probable that the commensal relationship is obligatory, and that *Typhloceuthophilus* lives nowhere except in *Geomys* burrows.

In Florida pocket-gophers occur almost exclusively in areas of well-drained, sandy soil—particularly in the "high pine-turkey oak" habitat that occupies the Norfolk sands, and less abundantly in the "sand scrub" on the dune-sand soils of the St. Lucie and Lakewood series. In these situations the pocket-gophers excavate extensive tunnel-systems, and the small mounds of sand removed from the burrows form a characteristic and conspicuous feature of the environment. The tunnels lie from four inches to several feet below the surface, but mostly at a depth of less than two feet; their diameter ranges up to about four inches, and the length of a single burrow and its branches may exceed 500 feet. The burrow of one pocket-gopher does not ordinarily communicate with those of other individuals, and has no openings to the surface of the ground except while the mammal is carrying out sand and building a mound. As soon as this operation is completed the short lateral tunnel through which the earth was removed is tightly plugged with sand, generally for a distance of several feet.

The food of Florida pocket-gophers is known to consist very largely of the subterranean parts of plants—roots, tubers, bulbs,

etc.—which they encounter while burrowing. Stores of such plant parts are frequently laid away in special chambers, and the animal's feces are usually disposed of in another chamber. Being largely or wholly herbivorous, pocket-gophers (unlike moles) are not dangerous to the arthropods commensal in their burrows except that the latter may be injured by being trodden upon or brushed against by the rodents, or buried during their tunneling operations.

An abundant supply of food for herbivorous and coprophagous insects is furnished by the rootlets and fungus hyphae in the tunnel walls, the stores of food laid up by the pocket-gopher, the grass nests which it constructs, and the animal's feces. Mites, Collembola and other small arthropods are present in considerable numbers, and are preyed upon by the larger carnivorous forms, among which *Typhloceuthophilus floridanus* is apparently to be numbered.

Nearly eighty species of arthropods (mostly insects) have so far been found in or trapped from *Geomys* burrows. The majority of these are of casual or accidental occurrence; but at least fourteen of the insects are apparently obligate commensals which are probably confined to the burrows. In addition to *Typhloceuthophilus* this group of obligates includes two small centipedes (both new, and one constituting a new genus, to be described by R. V. Chamberlin); one Lycosid spider (*Sosilaus spiniger* Simon, determined by H. K. Wallace); two ectoparasites of the pocket-gopher (the mallophagan *Geomydoecus geomydis* Osborn, determined by J. Bequaert, and a flea, *Foxella ignotus* (Baker) according to Wm. L. Jellison); six coprophilous beetles (the Scarabaeids *Aphodius geomysae* and *A. goffi*, new species recently described in this journal by O. L. Cartwright, and the Histerids *Spilodiscus floridanus* n. sp., *Atholus minutus* n. sp., *Geomysaprinus goffi* n. gen. et sp., *G. tibialis* n. sp., described in preceeding article of the *Annals* by E. S. Ross); an Anthomyiid fly (*Pegomya* n. sp., determined by D. G. Hall); and a Tineid moth (*Amydria* n. sp., determined by August Busck), the larvae of which feed upon *Geomys* dung.[10]

In view of the relatively complete isolation of the burrow-systems of individual pocket-gophers, both from the ground-surface and from the tunnels of other individuals, it is interesting to consider the means whereby their arthropod inhabitants are

[10]For a more detailed account of the burrows and their arthropod inhabitants, see the paper by Hubbell and Goff referred to in footnote 2.

dispersed. There is reason to believe that dispersal of the majority of the commensal species rarely if ever occurs by way of openings to the surface of the ground. The burrows are opened by the pocket-gophers only at intervals, and for short periods; the chances that most of the delicate arthropods could survive the higher evaporation rate and the attacks of predators outside the burrow long enough to locate another open burrow would appear to be slight. Furthermore, when the burrow is open during the building of a mound (the only times when occupied burrows are normally open except during brief nocturnal forays made by the rodents) the pocket-gopher is intensely active in the entrance, which would itself tend to discourage exit or entry of other animals. Lastly, it has been observed that the more vagile of the burrow insects—the moths, flies, and *Typhloceuthophilus*—all retreat from openings artificially made into the tunnels. This behavior is probably attributable to avoidance of air-currents and higher evaporation rate rather than of light, since even at night they will seldom enter a trap-pit intersecting a burrow unless the top of the pit is closely covered.

I believe that distribution of the commensal arthropods normally occurs through subsurface connections temporarily established between burrows, or by transfer of sections of tunnel from one burrow-system to another. Such connections and transfers may be brought about in several ways. (1) Pocket-gophers occasionally abandon their burrows and seek new locations. Such abandoned burrows may retain their arthropod faunas for months, as shown by field observations, though the commensal species are in time replaced due to infiltration of geophilous forms from outside. Not infrequently, however, another pocket-gopher may tunnel into the abandoned burrow, clean and plug it, and add it to its own burrow-system; an instance of this has been observed by Goff. If this occurs while the commensal population is still more or less intact it results in dispersal of the burrow fauna. (2) The tunnel of one pocket-gopher may accidentally intersect that occupied by another member of the same colony. As shown by study of completely excavated burrow-systems, the intruder may, before plugging the intersection, take advantage of its discovery by using the other burrow for the disposal of sand that would otherwise have been carried to the surface. During this operation a transfer of commensal arthropods may take place. Field observations indi-

cate that the flies, moths, and *Typhloceuthophilus* retreat along the tunnels before an advancing pocket-gopher, and they may thus be driven from one burrow to the other. Small insects and insect eggs may also be carried with the sand transported into the other burrow by the pocket-gopher. (3) Temporary communication is known to be established between the burrows of male and female pocket-gophers during the breeding season, and this may well be the normal means of dispersal of the burrow-inhabiting arthropods.

HABITS AND LIFE HISTORY

The following account is based on observations made over a period of twenty-two months on artificial colonies of *Typhloceuthophilus floridanus*, supplemented by field notes and analysis of collections.

Establishment of artificial colonies: Seventy-five living individuals of all sizes were collected on April 19–22, 1938, by C. C. Goff, during the excavation of a large *Geomys* burrow near Leesburg. On April 23 these were brought to Gainesville, and three days later were established in two glass-covered "observation burrows" in the enclosed, nearly dark, earth-floored space beneath my house. The "tunnels," about three inches wide and an inch and one-half deep, were made in sifted but unsterilized sand obtained from a field where *Geomys* burrows are numerous. One-inch holes drilled in the plate-glass covering the burrows permitted introduction of food, and were kept closed with smaller glass plates. In the case of the larger of the two burrows (I) the sand was placed in a trench about five feet long and six inches in breadth and depth, dug in the earth floor with one end near a small permanent pool formed by the drip from an ice-box, and the other extending out into relatively dry soil. In this burrow were placed seventy-one *Typhloceuthophilus* of all sizes. The smaller burrow (II), about eighteen inches long and with two short lateral branches, was constructed in a sand-filled wooden box, the dimensions of which are 30x20x6 inches. This box was supported on a bench of convenient height, so that one could seat himself before it while making prolonged observations. One pair of adults and one pair of last instar nymphs were placed in this burrow, each pair consisting of a male and a female.

Maintenance of the colonies: The plate of glass covering burrow (II) left exposed only a small marginal strip of sand

around the edges of the box; the sand was kept moist by occasionally pouring water into troughs scooped in these margins. In the case of burrow (I) the sand was kept sufficiently moist by seepage from the drip-pool mentioned above. Small quantities of food were introduced into the burrows at irregular intervals of from ten days to more than three months. Observations and notes have been made at intervals varying from several days to two weeks throughout most of the period since the establishment of the colonies, with interruptions of about six weeks during the summers of 1938 and 1939.

An electric headlight was used for watching the activities of the insects. The population of burrow (I) diminished rapidly, and observations on this burrow were terminated February 16, 1939. Descendants of the original insects placed in burrow (II) on April 26, 1938, are still living and healthy February 19, 1940; on this date one adult male and one adult female of the first generation reared from eggs in the burrow are still present, with several small nymphs of the second generation.

General observations: An evaporation rate such as prevails in the atmosphere outside of the burrows is rapidly fatal to *Typhloceuthophilus floridanus*. Adults and half grown nymphs kept overnight in the laboratory at Leesburg, in a glass jar with screen cover and containing moistened bran for food, were all dead and partly dry in the morning, though the humidity during the night had been high. Inability to withstand dessication doubtless accounts for the extreme sensitivity of the species to air currents. Individuals react negatively to direct sunlight, but do not appear to be able to detect the relatively cool though intense light of an electric torch or collector's headlight. In the observation burrows they will walk directly through the point of most brilliant illumination without change of pace or direction, and can be observed with the headlight for long periods without signs of disturbance. This makes it easy to observe activities which, in the case of other Rhaphidophorids, are carried on only in darkness or in dim light.

Overcrowding, leading to extensive cannibalism at the expense of individuals undergoing ecdysis, was probably one cause of the rapid decrease in population that occurred in burrow (I). It was also difficult to prevent entry of predatory forms, and a small Lithobiid centipede that gained access to the burrow probably killed many of the cricket-locusts before it was discovered.

Copulation: Between June 2 and August 24 copulation was observed on several occasions, both at night and during the day. The male and female assume a tail-to-tail position, with no parts of the body in contact except those at the end of the abdomen. The tip of the abdomen of the male is twisted about 90°, so that the male subgenital plate projects laterally from the base of the slightly upraised ovipositor. I could not determine whether or not the pointed apex of the pseudosternite was used to depress the margin of the female subgenital plate, but the position taken by the male would have made this possible. A slight disturbance is sufficient to cause the two insects to separate; but one pair that was watched for more than twenty minutes remained motionless the entire time, and the insects were still in copula when I left.

Spermatophores: Two females collected at Leesburg on April 15 held spermatophores in the genital chamber. These structures (text figs. 1, 2) are of a form not hitherto known among the Gryllacrididae, being adapted to the unique arrangement of the spermathecal ducts in the female. The portion of the spermatophore preserved[11] is a dark brown, thin-walled, bicornuate structure perched saddle-like on the summit of the spermathecal papilla. It consists of a relatively large mesal portion, containing an undivided cavity which communicates at each side with a pair of curved, tapering tubular ducts. The latter extend dorsad and cephalad, and have their apices so deeply inserted in the two openings of the spermathecal ducts[12] that it is difficult to remove the spermatophore without breaking off the ends of the tubes. The color and consistency of the spermatophore walls are much as in the spermatophore of *Ceuthophilus gracilipes*.

Eggs and Oviposition: Mature ovarian eggs taken from females collected at Leesburg March 30 and April 15 are elongate oval, very slightly curved, and with nearly hemispherical ends. They average about 2.8 by 1.1 mm. in size, and do not differ in appearance from *Ceuthophilus* eggs. Oviposition has not been observed. The ovipositor is probably used in the

[11]When freshly formed the spermatophores of the Ceuthophilini appear to be partly enclosed in a relatively thin mucous covering which soon deliquesces, and of which only traces are usually found in the genital chambers of females which have been trapped in molasses jars or preserved in dilute alcohol.

[12]So far as is known the spermatophores of all other Ceuthophilini have a single duct; except in *Pristoceuthophilus* (cf. footnote 8) this duct is inserted in a median spermathecal aperture.

normal manner to insert the eggs into the sand of the burrow floor. It should be noted, however, that no evidence of abrasion of the fine hairs and delicately crenulate margins of the distal part of the ovipositor has been noted in any specimen examined, whereas in old females of *Ceuthophilus* the teeth and apex of the ovipositor are often much worn. This, together with the unusually membranous and loosely connected proximal portions of the ovipositor, suggests the possibility that the eggs may be simply extruded from the gonopore chamber at the base of the ovipositor, and the latter used to rake sand over them.

Life History: Two first instar nymphs were found in burrow (II) on July 21, 1938, upon my return after an absence of six weeks. The fifty-seven days which had elapsed since the introduction of the pair of adults on April 26 may therefore be taken as the maximum time that could have intervened between oviposition and the hatching of these two individuals. In all probability the duration of embryonic development is closer to forty or forty-five days. These two nymphs (later found to be male and female), and a third male which hatched about August 3, were the only ones which hatched from eggs laid by the mature female originally placed in the cage.

Growth of these nymphs was very slow. Approximate measurements of size were made by laying a sheet of paper on the glass cover of the burrow above the specimens at times when the nymphs were pressed close against the lower surface of the glass, and drawing fine pencil lines opposite the ends of the body and of the caudal femur. (The nymphs could often be made to assume and hold this position by scratching on the sand, as described below). The following tabulation gives the measurements of the nymphs that were first seen on July 21 (the only two that reached maturity).

TABLE II

MEASUREMENTS (IN MILLIMETERS) OF TWO INDIVIDUALS OF *Typhloceuthophilus floridanus* AT INTERVALS DURING DEVELOPMENT

	First Instar July 21	Nov. 9	March 5		May 14		Adult (July 7) Measured Oct. 30	
	♂ ♀	♂ ♀	♂	♀	♂	♀	♂	♀
Length of body	2.0—	3.8±	6.8	8.0	7.6	8.3	10.0	10.4
Length of caudal femur		3.0±	4.4	4.7	5.2	5.6	6.7	7.1
Length of ovipositor				0.5±		1.8		4.8
Length of antenna		11.0±				19.5	16.0	15.2

On July 4, 1939, both of these individuals were still in the penultimate stadium, but when next observed, on the night of July 7, both had matured. The duration of the postembryonic period of development of these individuals was therefore not less than 349 days (about two weeks short of one year) and possibly somewhat longer. Under natural conditions the time taken to reach the adult stage probably more often exceeds than falls short of one year.

The original pair of adults placed in burrow (II) on April 26, 1938, died between August 5 and 24. The two last instar nymphs introduced into the burrow at the same time matured between May 25 and June 2. This pair was several times observed in copula, the last occasion being on August 24. The female died between November 5 and 9, and no nymphs emerged from eggs which she may have laid. The male remained active and apparently in good health until a few days before his death on June 20, 1939. His adult life endured at least 384 days (nearly three weeks longer than one year).

The individuals which hatched from eggs on or shortly before July 21, 1938, and which matured between July 4 and 7, 1939, were observed in copula on several occasions during the fall of 1939. On December 23, 1939, three small nymphs, one first instar and two apparently second instars, were seen in the burrow; both the parents were at this time active and healthy.

From the observations recorded above one may conclude that, under the conditions maintained in the artificial burrows, *Typhloceuthophilus floridanus* may live as long as 733 days after hatching from the egg. Adding a hypothetical 45 days for the duration of embryonic development, the individual life history under favorable conditions may extend over a period of about twenty-five and one-half months. It takes approximately one year to reach maturity, and individuals may live more than one year as adults. In the instance here recorded, the period from the hatching of one generation to the appearance of the next was approximately 510 to 520 days, or about one year and five months. So far as I am aware this is the first actual information that has been recorded concerning the duration of life of any member of the tribe Ceuthophilini, although in 1936 I suggested that the life cycle of some of the cavernicolous species of *Ceuthophilus* might occupy two or more years.

Field data on the occurrence of adults and nymphs of *Typhloceuthophilus*, together with observations made on the

artificial colonies, show that there is complete overlapping of generations. Oviposition is evidently continued throughout the year, and individuals of all instars are present in the burrows at all times. Furthermore, it is probable that the number of stadia in the individual life history is quite variable, though direct evidence of this is lacking. In the series of nymphs obtained from *Geomys* burrows there is complete gradation in body size and in degree of development of the ovipositor. The average number of stadia in the life cycle is probably closer to ten or twelve than to five or six.

Feeding habits: A variety of foods which had previously been found acceptable to *Ceuthophilus* was placed in the artificial burrows—small pieces of fresh meat, peanut butter, sugar, dried prunes and fresh fruit. The meat was eaten with avidity, and the sugar was apparently also visited, but the other foods were almost ignored. Bran flakes moistened with water were eagerly eaten by several nymphs caged in a jar in the laboratory, but may have been sought for the moisture, since the same food introduced into the artificial burrows was not seen to be eaten. On one occasion only, two small nymphs were seen eating the soft pulp of a prune. Adults would pull lumps of meat larger than their bodies about the burrows, as if trying to hide with them; sometimes two or more would engage in a tug-of-war over one piece of meat. After November 11, 1938, no food was given except fresh or cooked meat, small pieces of which were introduced on December 26, January 10, February 16, May 14, August 7, September 23, December 5 and December 23. On each occasion, when the meat became mouldy after a few days, the insects apparently ceased to feed upon it. The bodies of all individuals that died in the burrow were soon devoured by their companions, leaving only the head capsule, tibiae and ovipositor. Nymphs undergoing ecdysis were also attacked and eaten in burrow (I). The insects appeared well nourished and were active at all times.

In nature *Typhloceuthophilus* probably captures and feeds on small adult and larval insects and other arthropods. The only such forms present in burrow (II) were two species of minute Collembola (*Lepidocyrtus cyaneus* Tullberg and a slightly larger and less active whitish species, which eventually supplanted the former). These soon became very abundant, especially about the residues of the prune and the moulding meat. I believe that these insects were fed upon by the cricket-

locusts, and that this partly accounts for the success of this colony, as well as for the fact that even after weeks or months had elapsed since the last introduction of food the *Typhloceuthopilus* often gave no indication of an unusually ravenous appetite.

It may seem unlikely that the cricket-locusts, blind and apparently ungainly, could capture such small and quick-leaping prey as Collembola. However, sluggish as they often appear, spending hours completely motionless, the blind "crickets" are agile and graceful when wandering about. The body is carried lightly and as it were on tip-toe, with head protruded and the palpi flickering up and down in continual and very rapid motion, their tips exploring the surface of the ground ahead. On various occasions I saw individuals try to catch Collembola, without success. It was very common to see a wandering *Typhloceuthophilus* insert the mouthparts into every small cavity in the floor of the burrow, feeling with the palpi all over its interior; I suspect that small arthropods are often trapped and captured in these confined spaces. On August 24 a female visited the blackish debris of the prune, which was swarming with the minute whitish Collembola, and made a number of quick rushes at it, thrusting her head forward with shaking movements, palpi in violent motion and mandibles and maxillae probing the mass; between rushes she backed away and appeared to chew something. Her actions were not those of an insect feeding upon inert food, but of one engaged in capturing active prey. Unfortunately I could not see what she ate.

The cricket-locusts occasionally drank from drops of water condensed on the glass top of the burrow. On other occasions they were seen to press the mouthparts to the soil, remain motionless a moment, move a short distance and repeat the action; presumably they were drinking soil moisture.

Burrowing activities: Large nymphs and adults of *Typhloceuthophilus* were frequently seen digging in the walls of the observation burrows. By May 14 the walls of burrow (II) were pitted with more than twenty shallow holes, and beneath the glass cover seven longer burrows had been excavated. The tunnels made by the insects averaged about one-third of an inch in diameter, and varied from two to six inches in length; the longest one terminated in a pair of short, divaricate branches. The digging of each of these tunnels was the result of intermittent labor, generally by several individuals, over a period of

days or weeks. One tunnel was driven out from beneath the edge of the glass plate into a trench used for watering the sand, but none of the *Typhloceuthophilus* left the burrow through this opening.

The digging process was watched many times, and my notes on it are epitomized by the following observations, recorded on January 10. An adult male, after wandering about for some time, began to enlarge a shallow pit in the angle between the sand and the glass cover. The digging was done largely with the head and jaws, using the lower surface of the mandibles and labium to pull back small lumps of damp sand as with a hoe. The head was protruded and the jaws thrust into the sand (sometimes apparently biting it, sometimes closed); then the head was suddenly pulled down and backward at the same instant that the entire body was vigorously jerked backward by the legs. The skill and effectiveness with which the digging was done were as remarkable as the strength and abruptness of the movements. Small pebbles were removed by inserting the mandibles behind them and jerking them loose. The palpi were sometimes employed to rake together a heap of loose particles which could be thrown to the rear with a single movement of the head. Occasionally the fore legs were used to scrape at the surface of the excavation, either alternately, or more often by making several rapid strokes first with one leg and then the other. When the heap of loose sand beneath its body grew large enough to be inconvenient, the insect would back up, throw the sand back between the legs with rapid movements of the head, and work the pile toward the mouth of the hole till it rolled down into the main burrow. (*Typhloceuthophilus* was never seen to rake the sand back out of the way with the front legs, as *Ceuthophilus latibuli* has been observed to do). Digging was intermittent, the insect frequently withdrawing from the hole, running a few steps, and again returning to its task; after five minutes of such interrupted efforts the tunnel had been deepened by about one-third of an inch.

Behavior when disturbed: While apparently unable to perceive light, and unresponsive to ordinary sounds such as talking or whistling, *Typhloceuthophilus* is extraordinarily sensitive to earth vibrations. Almost instant cessation of all activity in the burrow may be caused by gently rubbing a pinch of sand on the glass cover of the burrow; scratching with the finger in the sand at the margin of the box is even more effective. After a moment

in which all the insects remain poised and motionless, they begin to scamper in all directions, and if the scratching is continued every individual will in a few seconds be ensconced in a safe retreat. Some disappear in the side tunnels which the insects have dug; others crowd their bodies into the smallest possible compass in one of the shallow pits in the wall of the burrow; still others apparently try to reach the roof of the tunnel and failing, press their bodies horizontally into the angle between the sand and the glass. This reaction never fails to occur no matter how often the experiment is tried, and is as marked in insects reared in the artificial burrows as in those captured in natural ones. To the observer this behavior irresistibly and comically suggests that the *Typhloceuthophilus* think they have heard the approach of a pocket-gopher, and are hastening to get out of harm's way and give it free passage. It is, undoubtedly, an adaptive response to the presence of the mammal. Together with the loss of eyes, it constitutes perhaps the best evidence that the relationship with *Geomys* is one of great antiquity, and a real instance of obligatory commensal and host.

FLEAS OF EASTERN UNITED STATES by IRVING FOX. Pages vii and 191, 166 figs., on 31 pls. 6x9 inches, 1940, cloth bound. Published by THE IOWA STATE COLLEGE PRESS, Ames, Iowa. Price, postpaid, $3.00.

Until very recently so few diseases have been thought to have been carried by fleas and as but few of these diseases have appeared on American soil the fleas as a group have received meager attention in this country. Being associated with animal and bird nests, smelly things at best, fleas have not attracted students as have butterflies and other gaudy insects. In 1895 C. F. Baker's Preliminary studies in Siphonaptera appeared in the Canadian Entomologist. In 1904 his Revision of American Siphonaptera . . . with list and bibliography of the group appeared in the Proceedings of the U. S. National Museum. Otherwise the literature on American fleas is a series of rather short papers mostly notes and descriptions of new species.

The most of the work on the present volume was done in the large collection of the U. S. National Museum. The area covered is east of the one-hundredth meridian exclusive of Texas. Fifty-five species, falling into five families comprising thirty-three genera, occur in this area. They parasitize about seventy-five mammalian and avian hosts including man and his domestic animals. At the back of the volume are a Synonymic Index, a Host Index, a Selected Bibliography of four pages and a general Index.

In our life experience we have rather deliberately avoided fleas so cannot judge the value of the numerous pages of illustrations. To us as an "artist" they appear hastily done but the setae and general contours are vigorously drawn. We believe that the volume is one that will stimulate interest in the group. It would have appealed to a wider audience, if it had covered references to the various species as carriers of disease. The paper used is unusually thick which should give the work lasting qualities under heavy laboratory use. In general the book is a credit to the author and to the publishers, the newly organized Iowa State College Press.—C. H. K.

A PROBABLE PRENUPTIAL GATHERING OF POLISTES

(Hymenoptera: Vespidae)

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1128 Oxford Road,
Winter Park, Florida

Several articles on "swarming" by *Polistes* of different species have been published from observations in China, Japan and elsewhere. Rau has written a number of papers touching on this and other habits of species of *Polistes* in Missouri and in the Canal Zone and other cases which have not come to the attention of the writer have probably appeared in print.

None of these accounts, however, seem entirely to agree with some observations made by the writer November 10th, 1939, at Winter Park, Florida, and which, therefore, are given here.

November 10th, 1939, was a clear day with a temperature at noon of between 75° and 80° F., though for a week before the night temperatures had gone as low as 50° to 55°. About 1 P. M. that day, chancing to look out of a window, the writer noticed several good sized insects flying rapidly about. On going out he found on a Water Oak tree (probably *Quercus nigra*) growing near the window a mass of insects gathered on a twig about one-fourth of an inch in diameter, the mass itself being approximately three inches in diameter, five inches long and cylindrical in form. The insects observed from the window, only about half a dozen in number, were flying around this mass which was about ten feet from the ground and much resembled a swarm of honey bees.

Fearing that, as with bees, the cluster might suddenly depart, an energetic sweep of a net captured all but about half a dozen of the insects and these were killed for examination.

The insects proved to be *Polistes exclamans* Vier. (determined by Dr. J. Bequaert) and the lot consisted of 40 males and 32 females, and probably totaled, including those missed, nearly 80 for the entire swarm. All were of the same color.

A search to discover where the swarm came from showed that about 25 feet from the twig to which the insects were clinging was a nest of this species which had been begun the

preceding June and had been gradually enlarged during the summer and fall and that no nest either of that or any other species of *Polistes* could be found anywhere else in the immediate neighborhood, so it would seem probable that the "swarm" came from that nest.

The writer does not find in the literature available any account of *Polistes* leaving their nest and clustering on the branch of a tree. Rau (Ann. Ent. Soc. Am., 24: 515, 1931) writes of ten individuals found huddled in a crack between two ceiling boards of a shed, four and eight feet from two abandoned nests September 11, 1930, but in the present case the cluster was 25 feet from any nest and entirely exposed on all sides.

The presumption in the present case would seem to be that the wasps left their nest together and massed on the twig preliminary either to dispersing and then mating, or mating before dispersal. If one may judge from the actions of other species of *Polistes* it would seem likely that after mating the death of the males would shortly follow and that the females would hibernate if the weather became cold, or would begin the formation of cells for new nests if the weather were warm. As the weather after November 10th was quite cold and in January, 1940, went as low as 20° where the swarm was found, it is probable that had the insects not been captured they would have hibernated.

A SYNOPSIS OF THE HEMIPTERA-HETEROPTERA OF AMERICA NORTH OF MEXICO, by J. R. DE LA TORRE-BUENO. Entomologica Americana Vol. XIX, pp. 141–310, 4 plates, 1939. For sale by the BROOKLYN ENTOMOLOGICAL SOCIETY, 28 Club Way, Hartsdale, N. Y. Price, $2.50 paper bound; $3.50 cloth bound.

Entomologists will be interested in reprints of the recent review of the order Hemiptera, appearing in Entomologica Americana. Part I includes a key to all the families, and keys to genera and species for the Scutelleridae, Cydnidae, Pentatomidae, Aradidae, Dysodiidae, and Termitaphididae. Subsequent parts are to be presented until all the families are treated in a similar manner. A list of new genera and species described since Van Duzee's Catalogue (1917) with references to literature is appended. To assist those who use the keys, there is given approximately eight pages of definitions of terms employed and four plates of line drawings illustrating Hemipteron terminology. Only characters and structures readily accessible, plainly visible and clean-cut are used in the uniformly written keys that are either original or recasts of extant ones. For each species of the families treated in detail there is given distribution records by states, feeding habits and host plants as known.

This scientific paper is a valuable addition to the literature of the Hemiptera and entomologists will look forward to the completion of this worth-while endeavor.—R. H. D.

THE RESPIRATORY MECHANISM IN THE GRASSHOPPER

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The respiratory system of insects accomplishes direct gaseous exchange between the tissues and the atmosphere by means of a complicated mechanism. It has been a subject of investigation since the seventeenth century.

The morphology of the respiratory system has been carefully studied. In this work as well as in physiological investigations certain of the Orthoptera have been used because of their large size and representative structure. Conclusions from such studies may be applied generally to all of the more active insects which make free use of their wings. Vinal (1919) describes the gross morphology of the tracheal system in grasshoppers. Snodgrass (1931) describes what might be considered the accessory respiratory mechanism, that is, the abdomen and respiratory muscles.

Packard (1898) discusses the microscopic structure of the system. He discusses the work of Wielowiejski and C. von Wistinghausen, and describes their work in attempting to determine the nature of the tracheal terminations. It is in these structures, the tracheoles, that most, if not all, of the gaseous exchange is thought to take place.

Functional aspects of breathing appear less well understood than the structure of the system. Plateau (1884) reported the results of a study of the respiratory movements in insects, especially the abdominal movements. Regen (1911) made a similar study. Lee (1925), on the other hand, investigated the function of the spiracles. His work was largely supported by Mackay (1927), McArthur (1929), McGovran (1931), and Kitchel and Hoskins (1935) with similar investigations. Du Buisson (1924) attempted to determine the relationships between abdominal and spiracular movements by direct observations.

[1]I wish to express my appreciation for the generous assistance of Dr. Floyd J. Brinley in making some of the observations. Acknowledgment is also due Dr. Z. P. Metcalf and Dr. B. B. Fulton for making helpful criticisms of the manuscript. This work was done in the Zoology Laboratories at North Dakota State College.

His conclusions conflicted with those of subsequent investigators, and they have been questioned by Uvarov (1928). A comprehensive review of the subject of insect respiration is given by Wigglesworth (1931).

A review of these investigations gives the following conception of the respiratory system. The tracheal system in Orthoptera consists of arborizing tubules. The lumens are maintained by the presence of chitinized folds, the taenidia, spirally situated in the walls. Tracheae frequently anastamose, and many of the finer branches, the tracheoles, end blindly as liquid filled filaments a few microns in diameter. Like blood capillaries these tracheoles communicate with all tissues, and they largely supplant connective tissue. The rigidity of the tracheae is broken at frequent intervals by air sacs. These are greatly expanded portions that lack taenidia. The air sacs vary in size and number in proportion to their distance from the spiracular openings. By far the largest pair occupy the prothorax. Each spiracle after the first has a relatively large sac in immediate relation to it, and increasingly smaller sacs accompany the diminishing tracheal trunks. The tracheal trunks have access to the atmosphere through ten pairs of spiracular valves located along the sides of the thorax and abdomen.

Aeration is achieved through the "bellows effect" of the rise and fall of the sternal segments. In the Acrididae both inspiratory and expiratory muscles are found, although in many groups only expiratory muscles occur. There is a generalized circulation of air (Lee, 1925; MacKay, 1927; McArthur, 1929; McGowan, 1931; Kitchel and Hoskins, 1935). The first four pairs of spiracles serve for inspiration and the last six for expiration. The respiratory cycle is now thought to consist of an inspiratory phase followed by an expiratory phase (Rogers, 1938).

One of the major problems in the study of respiration in Orthoptera and other active insects has been the method of supplying air to the tracheoles. The existence of a pressure within the abdomen and tracheal system of sufficient magnitude to accomplish this seems necessary (Packard, 1898; Folsom and Wardle, 1934). How such a pressure might be created has not been shown. Nor has the existence of such a pressure been demonstrated. According to the current description of the mechanism, the system is essentially open to the atmosphere at all times; therefore, it is difficult to postulate any appreciable intratracheal pressure. Diffusion has been suggested as an alternative means of getting oxygen to the tracheoles, but

Krogh (1920a) believes that diffusion alone is probably inadequate for any but the less active insects.

The function of the air sacs is another problem. It has been suggested that they serve to lighten the insect, that they function as air reservoirs, and (Lee, 1929a) that they increase the volume of air exchanged with each respiratory cycle.

OBJECTIVES

The object of the following experiments is threefold: first, to study the correlation of parts involved in breathing movements; secondly, to investigate the functions of the air sacs; and thirdly, to make direct determinations of the intratracheal pressure and its variations during the respiratory cycle.

MATERIAL

The experimental insect for this investigation was the grasshopper, *Dissosteira carolina* Linn. Specimens were raised from refrigerated eggs which were incubated at successive periods so that fresh, normal material was always available for experiments. The grasshoppers were kept in wire cages and provided with moist lettuce leaves. In all cases the specimens that were used for investigation were returned to cages with the remainder of the hatch and lived the normal period.

CO-ORDINATION STUDIES

Method.—The following group of experiments was made to determine graphically the relationship of the various respiratory movements.

With the apparatus shown in Figure 1, the abdominal movements, which may be considered the basic respiratory movements, were recorded mechanically and independently. Simultaneously, attending movements were recorded by an observer. The vertical alignment of writing points was carefully adjusted. Subjective error was minimized because the observer's attention was directed to a single structure. When two observers were employed the results were later checked by independent observation, and in all cases sufficient records were taken to eliminate observational error. The time stated in the following explanations is relative and for the purpose of comparing a single cycle. The rate and regularity of respiration in insects vary greatly. (Herber and Slifer, 1928).

The specimen was held in position by clasping the wings with self closing forceps as close to the pronotum as possible without displacing the abdomen. The "H" shaped platform was made of clean pieces of photographic plate assembled with deKhotinsky's cement. The plate served as a base upon which the insect could place its legs in a normal position, and it prevented dislodgment of the attachment hook.

The recording lever was attached to the abdomen of the specimen by means of a small glass hook. The angle of the hook was about 85° so that when hooked under the overlapping posterior edge of a sternal segment a slight tension upon the thread would hold it in position. This

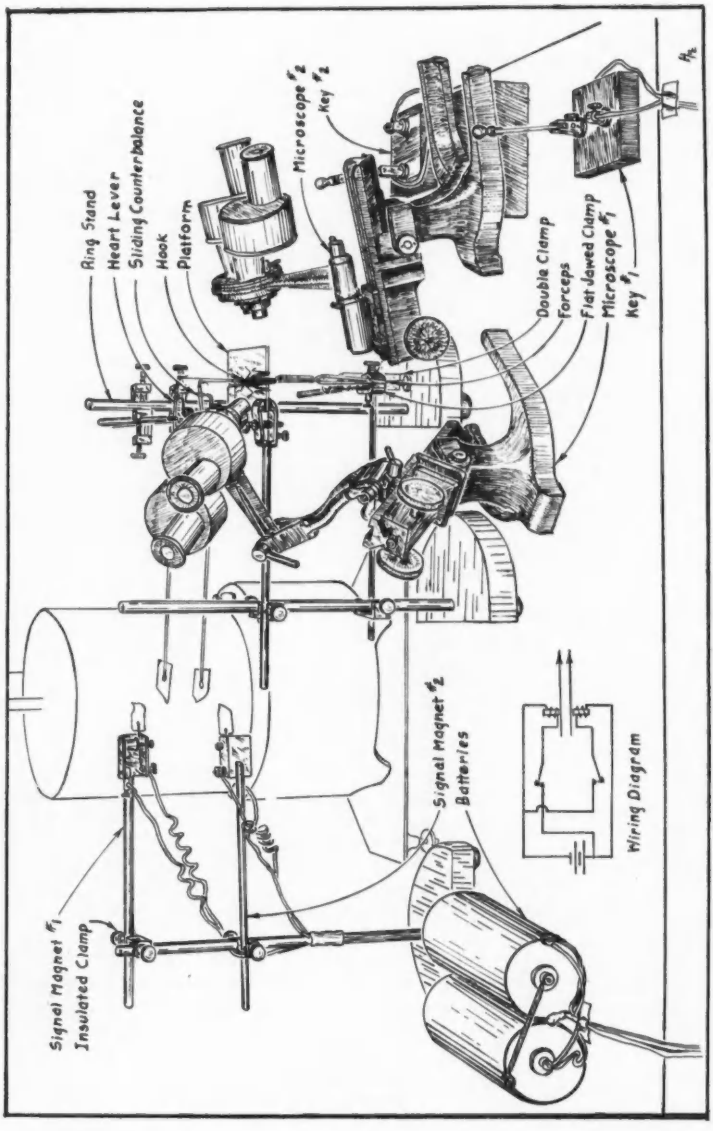

Fig. 1. Apparatus to record respiratory movements.

method had its own safety factor, for if too much tension was applied the hook slipped off.

For convenience in inserting hooks to record simultaneously the anterior and posterior segments the specimen was placed in an inverted position. Later records made with the animal in an upright position indicated that position did not influence the results.

The spiracles could be observed through the transparent platform. A convenient magnification was focused upon the spiracle, or part under investigation, and a record of its open and close movement was made by making and breaking contact in the signal magnet circuit. For the study of normal respiration the apparatus was set up and permitted to operate for an hour before a record was made. Slight stimulation of grasshoppers greatly alters the respiratory type, as will be shown.

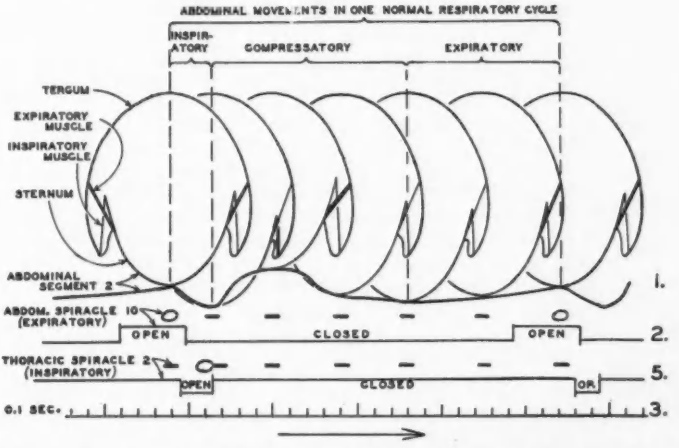

Fig. 2. Diagram to analyze the correlation between abdominal movements and the condition of spiracular valves during a single *normal* respiratory cycle. Lines 1, 2, 5, 3 are taken from Record I, Fig. 6. Superimposed on the graph is a diagrammatic cross section of abdominal segment 2 to show the movements of the sternal segments and the condition of the respiratory muscles (heavy lines indicate muscles contracted). Directly below each segment the condition of the spiracular valves is shown at that stage of the cycle (0 indicates valve open, — indicates valve closed).

Results.—Observations were made to ascertain whether the action of spiracle II was synchronous with that of the inspiratory spiracles, while that of spiracle X was synchronous with that of the expiratory spiracles; and whether spiracles of a segmental pair were synchronous. Because they are easy to observe these two were, therefore, used as indicators of the valvular conditions during the respiratory cycle.

Record I, fig. 6, shows the respiratory cycle to consist of three phases. Presuming the cycle to begin with an inspiration these are in order (a) inspiration, (b) compression, and (c) expiration. (See Figure 2). The phases will be discussed in that order.

The abdominal movement of decompression during the inspiratory phase is brief and of intermediate magnitude. It lasts about 0.25 seconds. Actual inspiration must occur only while the inspiratory spiracles are open during the last 0.2 seconds. These spiracles close just before the inspiratory movement of the abdomen is complete. The complete retention of inspired air is thus assured.

The compressatory movement of the abdomen, that period of maximum contraction, is about twice the magnitude of the expiratory phase. It gains its maximum rapidly and diminishes as rapidly to an amplitude about that of the expiratory minimum. The first portion of this phase is quite regular in amplitude and duration. It lasts about 0.7 seconds. The last portion is less regular averaging about 0.4 seconds. An irregularity in the cycle appears on Record I which seems to emphasize the importance of the compressatory phase. The second compressatory phase on the record was preceded by a long expiratory phase. It was followed not by an expiratory or inspiratory phase but by a second compression—then there followed a normal cycle.

The expiratory phase approaches its maximum gradually and falls away quickly into the inspiratory phase. It varies between 0.5 and 1.4 seconds and appears to be the most irregular of the phases. The long expiratory period on the record is followed by two compression phases as mentioned above. The expiratory spiracles open 0.3 to 0.4 seconds before the maximum and remain open 0.1 to 0.2 seconds into the inspiratory phase. In some instances the valvular action is not regular. The valves may open and close two or three times during the normal open period of about 0.4 seconds.

Contraction of the anterior segments of the abdomen, though of equal period and simultaneous with the posterior segments, is of greater amplitude.

Records II and III, fig. 6, indicate that a cycle quite different from the normal appears under dyspneic (forced breathing) conditions. Dyspnea was created by mechanical irritation, heat, or a drop of ether with similar results. The difference in the cycle is due to the merging of the compressatory and expiratory phases into one phase. The cycle under these conditions would consist of two phases, (a) inspiratory and (b) expiratory, if abdominal movements alone are considered. There is an interval before the expiratory valve opens, however, during which compression occurs. This may be considered as the compressatory phase, analagous to that of the normal cycle. (See Figure 3).

The inspiratory or decompression movement of the abdomen occupies about 0.5 seconds. The inspiratory valves open about 0.1 second after the phase begins and remain open for about 0.45 seconds. This phase is longer and of greater magnitude than the normal.

The combined movement in the compressatory and expiratory phases is characterized by a gradual rise to the maximum. About 1.7 seconds is occupied by this movement. The expiratory valves open before the maximum is attained and remain open about 0.7 seconds, or about 0.1 to 0.2 seconds after the inspiratory phase begins. This phase is considerably shorter than the combined time of the normal compressatory and expiratory phases.

There are places on the body of a grasshopper where the integument is thin and free from pigment. Through these the air sacs can be seen to collapse and fill. The most favorable place for this observation was found to be on the side of the abdomen, at the beginning of the fold of the intersegmental membrane between the first and second abdominal segments. A series of sacs located in this fold can be seen distinctly. The momentary collapse of one of these sacs was used as an indicator to study the pressure changes at a point well removed from the spiracles and the main trunks. Records IV and V, fig. 7, were made to determine the relationship between the abdominal movements and this collapse. The sac observed was about 0.1 mm. in diameter and the connecting tracheae about 0.01 mm. It was considered to represent an intermediate stage along the system

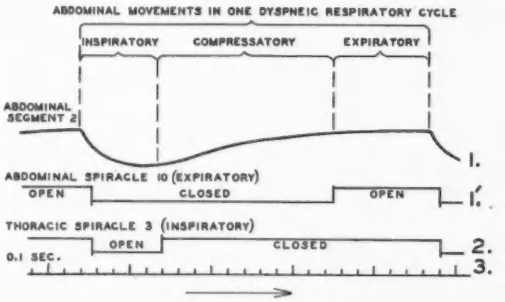

Fig. 3. Diagram to analyze the correlation between abdominal movements and the condition of spiracular valves during a single *dyspneic* (forced or labored) respiratory cycle. Lines 1, 2, 3 are taken from Record II, Fig. 6, and line 1′ is taken from Record III, Fig. 6. Comparison with Figure 2 may aid in visualizing the condition of the valves and sternal segments.

Record IV, fig. 7, shows that during normal breathing the minimum relative pressure (indicated by collapse of the air sac) in the tracheal system at a point well removed from the spiracles occurs soon after but *not during* the compression maximum (indicated by abdominal contraction).

Record V, fig. 7, shows that during dyspnea the minimum relative pressure occurs soon after the compression peak is passed, though this brings it during or at the close of the *inspiratory* phase.

Record VI, fig. 7, shows the correlation between movements of head and pronotum and abdominal movements during dyspnea. The forward movement is seen to occur during the compressatory and expiratory phases; it is correlated with increased intracoelomic pressure.

Discussion.—Record I, fig. 6, and fig. 2 reveal a mechanism whereby a pressure is created and built up within the tracheal system. It shows the synchronization of the parts involved in normal respiration. It seems obvious that respiration under *normal* conditions is not the simple process ordinarily described. The contraction of greatest amplitude is

found to occur when *all of the valves are closed*. It can have but one effect—the creation of a pressure which momentarily exceeds that of any previous condition, because it follows an inspiration which has filled the main trunks with air. The term *compressatory phase* is given to this period. The first part of this phase is active and involves the expiratory muscles, but the last part is apparently passive recovery due to elasticity and internal pressure. The expiration and inspiration are both active and involve corresponding muscles. Expiration is prolonged with the valves open for a longer period than inspiration. The reaction from the period of compression may be so delayed that this prolongation is necessary to displace a volume of air equal to that inspired during the shorter inspiratory phase. Reasons for this will be suggested below in the discussion of the air sacs.

During dyspnea there is an adjustment in the relationship of respiratory movements to accommodate increased oxidation. The mechanism permits an increased volume of air to be inspired, compressed, and expired in a decreased period of time.

The study of pressure conditions in the more remote regions of the tracheae is aided by Records IV and V, fig. 7. Lee (1929a) has suggested that the air sacs are simply to increase the capacity of the system; that they fill by atmospheric pressure at inspiration, wherever they are located, and collapse and empty at expiration. Then the maximum of collapse should appear coincident with the maximum of abdominal pressure at the time the expiratory valves are open. This is the condition in the large sacs at the main trunks, but the records show quite a different situation to exist in the distal sacs. These sacs may collapse during inspiration. (See Record V, fig. 7).

These data suggest a mechanism for insect breathing different from the present conception (Rogers, 1938) of alternating inspiration and expiration. Records II and III, fig. 6, and fig. 3 support the present view in so far as the relationship of the inspiratory and expiratory valves to the respiratory movements is concerned. It can easily be seen how the absence of graphic aid or observation of specimens which were not breathing normally might lead to a mistaken conception that the breathing mechanism involves only inspiration and expiration. The conditions shown in Record I, fig. 6, however, indicate a functional relationship of valves and abdominal movements which produces a mechanically distinct compressatory phase. This persists during dyspnea (Records II and III, fig. 6), though mechanically obscured so far as abdominal movements are concerned.

The following mechanism is suggested for respiration in the grasshopper. A resistance gradient must exist along the tracheae due to their diminishing size. As it approaches a maximum in minute distal tracheae the resistance must be high—higher than the difference in intratracheal pressure which results from the pressure decrease created by abdominal expansion. Inspiration, therefore, involves only the main trunks and sacs. The subsequent compression increases the pressure suddenly to such a degree that the resistance along the tracheal branches is overcome, *but not as a whole*. Rather, as the pressure increases at any instant the resistance in a portion of the tube is over-

come, and it is expanded. The air surges into the terminal air sac for that portion until it is sufficiently distended to permit the pressure to further mount and overcome the resistance in the following section. The volume of air in a sac increases more rapidly than the following constricted segment of trachea conducts it to the next sac. This causes the pressure to increase momentarily in excess of that necessary to distend the following portion of the trachea. The tracheae offer considerable resistance to distension or collapse, but the taenidia cannot conceivably render them rigid. When the pressure becomes high enough they would be expanded by the surge of air, and a volume would pass through until the pressure fell to such an extent that the elasticity and resistance of the tube exerted itself; then the flow would diminish abruptly. The tracheae may be considered, therefore, to act as valves between the air sacs. Then a very abrupt pressure rise and fall would be expected between consecutive sacs.

Having reached the maximum compression, the abdomen relaxes and the hemocoelomic pressure rapidly decreases. Air moves freely along the larger tracheae near the main trunks so that the pressure equalizes there quickly. Passing along the finer portions, however, is an activity the reverse of that which occurs during compression. The pressure decreases in a sac until the difference between the pressure in it and the following sac is sufficient to distend the connecting tracheae. Then a surge of air passes toward the spiracle, and the sac collapses momentarily only to attain a similar pressure relation with the next more remote sac and again be distended in turn. These remote sacs are then under a pressure in excess of the atmospheric pressure which fills the larger sacs. At the time the next compression phase occurs they will respond with an immediate pressure increase. This type of mechanism involves a delay in the collapse of more remote sacs. The sacs in communication with the larger tubes will fluctuate coincidently with the respiratory movements of the abdomen; those more remote will fluctuate at a progressively later period in relation to the size of the communicating trachea. This delay has been shown in Records IV and V, fig. 7.

The greatest difficulty in visualizing this mechanism appears to be that of obtaining a pressure differential between any parts of the tracheal system. The system would appear to have a uniform pressure throughout, since the hydrostatic pressure in the hemocoel must be uniform according to Pascal's Law. In order to demonstrate some of the factors which operate in this mechanism, a model (fig. 4) was constructed.

In the model, sacs S_1 and S_2 are toy balloons. Balloon S_1, when collapsed, was about 9.0 cm. long and S_2 was about 3.0 cm. long. They could both be opened to the atmosphere or connected to each other through the three way stopcock Sc. These balloons represent air sacs in the tracheal system. Vessel V, a glass bottle filled with water, represents the hemocoel. It was connected by rubber tubing with bottle L which was partly filled with water. By changing the level of L pressure changes in V could be created. This is analagous to the contraction and expansion of the abdomen of the grasshopper changing the volume of the hemocoel. To bring about more rapid changes than was possible by

raising and lowering L, a rubber bulb B was used. This could be compressed by hand to simulate the rapid volume changes of inspiration or compression. Passage of air into either sac was shown by a drop of water in each tube leading to the balloons. These indicators (I_1 and I_2) also showed the pressure differential between S_1 and S_2.

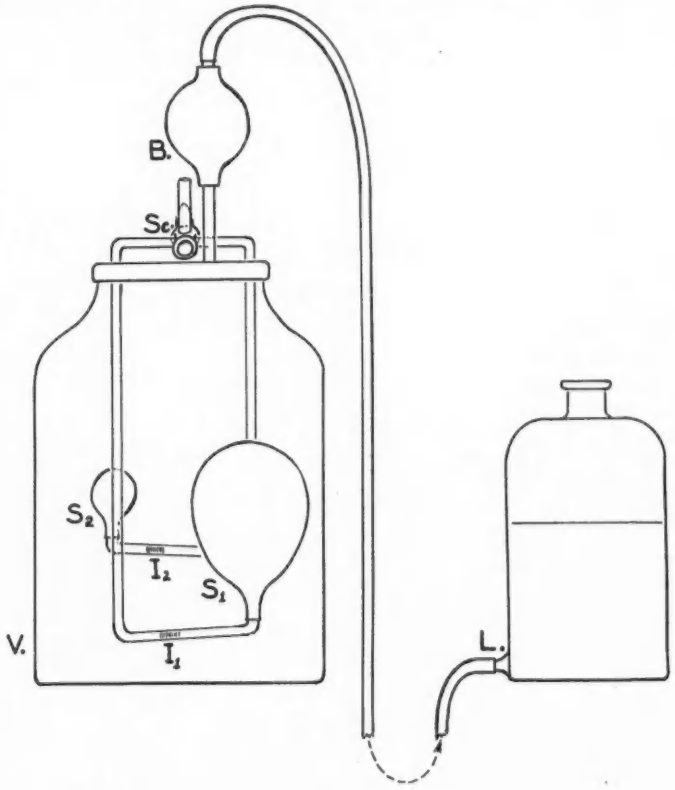

Fig. 4. Model to demonstrate pressure changes in tracheal system. See text for description.

When L is lowered water passes from V, and S_1 and S_2 fill with air if the stopcock Sc is open. S_2 does not become distended, however, but S_1 continues to fill and becomes greatly distended long after air ceases to enter S_2. The system is thus allowed to come to equilibrium with L about 12 inches below V. If the stopcock is now turned to connect S_1 and S_2 and close them from the atmosphere, and L is raised about 18 inches, pressure is created in V and thus in the sacs. Pressure is momen-

tarily greater in S_1 than S_2, however, for the indicators move toward S_2. When bulb B is suddenly compressed under these conditions, air is forced from S_1 to S_2. This is again shown by the indicators.

The pressure changes and the movement of air in the model depend on the difference in size of the sacs and the relative compressibility of gas and liquid. According to Pascal's Law, the pressure at any point in a liquid in a closed vessel is transmitted undiminished to every portion of the vessel. Therefore, the pressure per unit area on S_1 and S_2 must be uniform. The total force (F) on S_1 equals the pressure (p) multiplied by the area (A),

$$F = p.A$$

Similarly for sac S_2, the total force (f) for its area (a) is

$$f = p.a, \text{ therefore}$$

$$\frac{F}{f} = \frac{A}{a}, \text{ and } F = \frac{A}{a}.f$$

There is thus developed in the two sacs a differential force which is proportional to their difference in area. Momentarily, the air in S_1 is compressed more than in S_2 and a portion moves into S_2. When an equilibrium is reached the pressure in the two sacs and in the liquid will be the same. But the compression has accomplished a transfer of air from the large sac to the small one under an increased pressure over that at which they filled. Analogous changes can occur in the tracheal system of the grasshopper.

The order of events in dyspneic respiration is overshadowed by the merging of compression and expiration movements of the abdomen with the absence of a distinct compressatory movement. However, the mechanism may be explained similarly to that of normal respiration. The demand for increased aeration must be satisfied by the exchange of an increased volume in a given period. Mere speeding up of the normal cycle would not noticeably increase the volume exchanged during a unit of time because of the shallowness of the inspiratory movement. A more efficient means is to supplement the increased rate of inspiration by increased depth. In order to accommodate the increased volume of air, the exchange portions of the cycle must be exaggerated and prolonged. This is accomplished by increasing the depth of inspiration and expiration, and by increasing the open period of the valves. Because of the augmented volume of air inspired, the pressure within the system reaches maximum for the terminal tracheae early in the compression period. Evacuation of the entire system is much more complete because of rapid removal, under pressure, of a large volume of air. The air sacs are more completely emptied and filled with each exchange, because the intratracheal pressure gradation is proportionally exaggerated by the opening of the expiratory valves and active decompression in the main trunks. The pressure on the spiracle side of a remote sac may not decrease enough to cause collapse until during or after inspiration because of the delay already accounted for (see Record V, fig. 7). The result of such a breathing cycle could conceivably be a "building up" of the pressure within the system, since a delay in the emptying of the small sacs causes a partial overlapping of inspirations.

Record VI, fig. 7, indicates this "building up." The increased volume and pressure of the air held within the tracheae during dyspnea causes the intersegmental membranes to swell and protrude, particularly around the head. The exaggerated respiration creates an increased pressure with each cycle, so that the head and pronotum are forced forward with each compression. Lee (1925) noticed this forward movement and considered it to be an active movement serving to clear the first spiracles and permit better access to the air. Its relationship to abdominal movements does not suit this explanation.

STUDIES OF INTRATRACHEAL PRESSURE

Study of the mechanics of breathing in the grasshopper has suggested a mechanism which involves important pressure changes in the system. It seemed desirable to demonstrate, if possible, the existence of an intratracheal pressure.

The experimental specimens were normal adults. In view of the possible disturbing influences which attended the preparation of the material for observation, a period of from 24 to 48 hours was allowed to elapse before records were made. Within an hour after preparation the insects appeared to be quite normal. Grasshoppers were kept mounted for varying periods up to 12 days, during which normal feeding and evacuation occurred. At the close of experiments the specimens were restored to preceding conditions as nearly as possible, and they lived the normal period.

Method.—The apparatus is pictured in fig. 5. The essential feature, the mounting of the capillary manometer, required special technic.

The second thoracic spiracle is most conveniently located for the type of attachment used. It lies above the mesocoxal cavity in a small plate, the peritreme, which is flanked by similar plates, the episternum and the epimeron. The valve is a large, bilobed structure which protrudes from the rigid, chitinous background afforded by the surrounding plates.

It was necessary, before mounting the tube, to hold the insect firmly in a fixed relation to it. To relieve strain at the union of the specimen and tube, they were supported as a unit. A platform was made, as for the first group of experiments, in an "H" shape. The portion supporting the subject, a piece of glass about a centimeter square, was cemented to the crosspiece to make an elevation above the level of the main surface. Thus elevated, the animal's feeding movements were free. The jumping legs were removed at the autotomous joints. The sternal portion of the thorax was fastened to the platform with softened beeswax. (M. P. approximately 60° C.)

The manometer tube is detailed in fig. 5. The capillary was drawn from a $\frac{1}{8}''$ tube so that the internal diameter approached 0.1 mm. The optimum size was determined by elimination. A jacket was necessary to remove the marked effects of temperature fluctuations. An indicator of paraffin oil was used.

Standard pink dental wax (M. P. approximately 60° C.), and asphaltum varnish were used to attach the tube. To prepare the animal for the tube attachment the platform was supported along its long axis

in a flat jawed clamp. In order to determine the intratracheal pressure changes it was necessary to hold the spiracular valve open. For this purpose a piece of glass rod, 4.0 mm. long and large enough to hold the lips of the valve apart without occluding the opening, was bent at right angles 1.0 mm. from the end. The short end was inserted in the valve and held in place by sealing the long end to the integument with wax.

A wall of wax was then formed around the spiracle. To do this the mesocoxal cavity was first built up with wax to the level of the peritreme. A gasket was made from a sheet of wax of a thickness just exceeding the height of protrusion of the spiracle from the surface. A hole the size of the peritreme was made in the wax and the gasket then

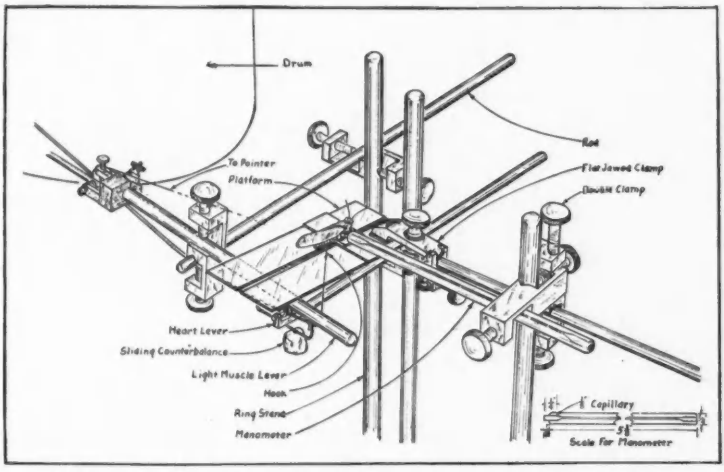

Fig. 5. Manometer attachment to study and record intratracheal pressure changes.

cut to the external diameter of the end of the manometer. This gasket was softened, centered over the spiracle, and pressed firmly against the thorax to adapt it to the contour of the area. It was carefully sealed at all margins to the integument by the use of a hot dissecting needle.

The platform was then placed in the mounting clamp together with the manometer. The end of the capillary tube was adjusted close to and parallel with the gasket. It was then butted against the gasket and sealed with a hot spatula. The gasket and joints were covered with asphaltum varnish. The immediate response of the indicator drop at the instant the tube was sealed to the gasket always demonstrated whether or not the rest of the seal was intact. The heat necessary for this procedure was in very restricted areas; it was limited in intensity to the temperature of the melting point of the wax, and was applied only momentarily. The effects appeared to be only a local irritation from which recovery was rapid.

A light muscle lever was used to record movements of the indicator drop. A thread was fastened to a pointer clamped to a mechanical stage on a binocular microscope. The pointer was arranged to extend over the manometer tube. The movement of the indicator drop was followed with the pointer and was in turn transmitted through the stage and thread to the recording arm. The abdominal movements recorded themselves simultaneously and independently as in the earlier experiments.

Mineral oil was selected as the indicator because of its low volatility. The pressures varied so greatly in force, duration, and rapidity of change that it was necessary to select by elimination the proper relationship of capillary size to length of indicator drop. Oil placed in the open end of the tube was moved toward the valve without irritating the grasshopper. This was done by means of carefully exerted pressure through a rubber tube. In this manner the size and position of the indicator drops could be varied. In all cases the indicator was kept as close to the spiracle as possible in order to minimize the effects of the compressibility of air.

The measurement of markedly varying pressure in such a small volume of gas is difficult. There are many variable factors in the method used here. The results demonstrate the existence and variations of pressure but they are only relative. An indirect method to be mentioned later was used to approximate the values of the pressure changes, but any quantitative readings of volume and pressure changes will require considerable modification and refinement of apparatus.

Results.—General observations were made before taking records. It was found that during normal breathing a single indicator drop about 1.0 mm. long was most useful. A fairly constant reciprocal movement occurred. For dyspneic breathing a drop 5.0 mm. long was used. This condition was accompanied by much more violent motion of the indicator. Various means were employed to induce dyspnea with similar results. The simplest was to let a drop of ether fall near the grasshopper.

EXPLANATION OF FIGURE 6.

Record I. Relation between inspiratory and expiratory spiracles, between spiracles and abdominal movement, and between posterior and anterior segments. Normal.

Traces: 1. Abdominal segment 2—contraction ascending.
2. Abdominal spiracle 10—lower line closed, upper line open.
3. Time 1/10 second.
4. Abdominal segment 5—contraction ascending.
5. Thoracic spiracle 2—upper line closed, lower line open.

Record II. Relation between inspiratory spiracles and abdominal movement. Dyspnea.

Traces: 1. Abdominal segment 3— contraction ascending.
2. Thoracic spiracle 2—upper line closed, lower line open.
3. Time 1/10 second.

Record III. Relation between expiratory spiracles and abdominal movement. Dyspnea.

Traces: 1. Abdominal spiracle 10—lower line closed, upper open.
2. Abdominal segment 3—contraction ascending.
3. Time 1/10 second.

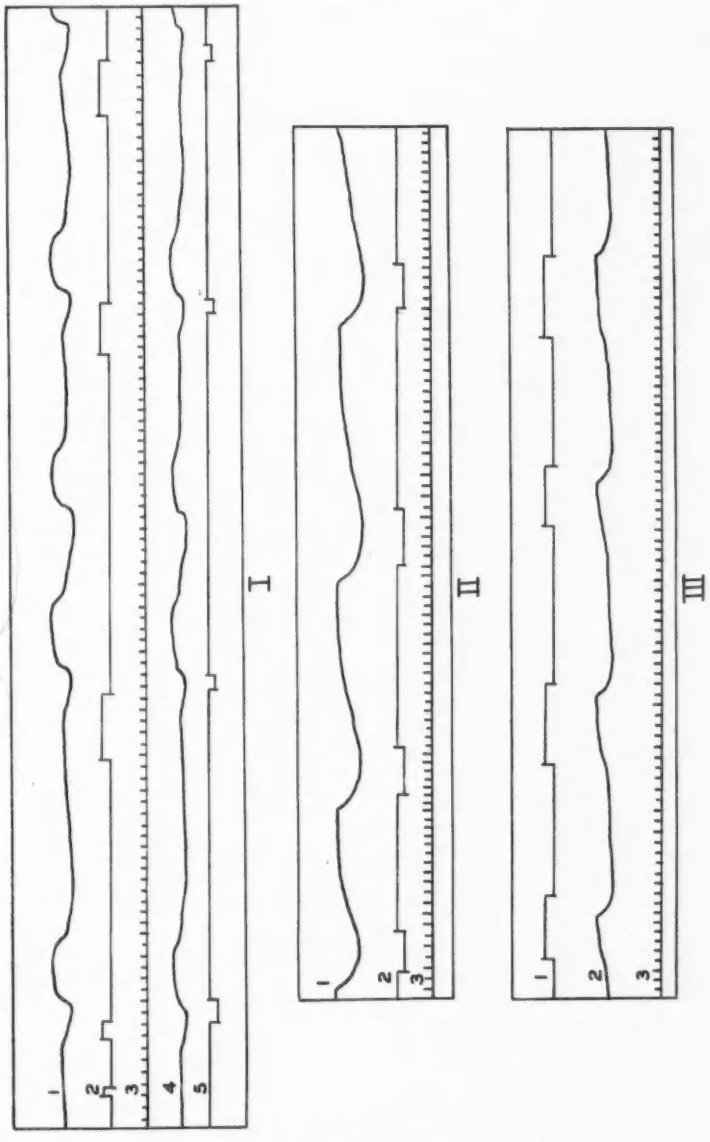

Fig. 6. Tracings of Kymograph Records.
All records read from left to right.

Under this condition the indicator moved back and forth in a path about 6.0 mm. long. The movement was exceedingly rapid, with a pause at each extremity of the path.

The most marked results were obtained when bodily movements were induced. Raising and lowering of the entire abdomen or its longitudinal extension, leg movement, wing movement, and movements of the head caused the most violent movement of the indicator. This was especially pronounced during feeding. Violent movements of the head and mandibles were induced by holding a lettuce leaf just out of reach of a feeding specimen. As a result of these movements the indicator occasionally shot forward over 2.0 cm. at each contraction of the abdomen with only slight return at expansion. A small drop disappeared on the sides of the tube after one or two such movements, and a larger drop was forced completely out of the tube.

These observations indicate that muscular movements as well as the respiratory movements are accompanied by a corresponding increase in pressure. Maximum increase appears to occur when the crop and intestine are filled, and the most effective movements seem to be those involving the head. It is reasonable to assume that the location of air sacs in the tissues would cause any movement which produces local compression to be translated directly into increased aeration in the region of contraction. It also seems reasonable to expect that any variation in abdominal contents would exert a corresponding effect upon the tracheae, for it would amount to a variation in the volume of

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EXPLANATION OF FIGURE 7.

Record IV. Relation between abdominal movement and the collapse of a remote air sac. Normal.

Traces: 1. Air sac—Lower line expanded, upper line collapsed.
2. Time 1/10 second.
3. Abdominal segment 3—contraction ascending.

Record V. Relation between abdominal movement and the collapse of a remote air sac. Dyspnea.

Traces: 1. Air sac—Lower line expanded, upper line collapsed.
2. Abdominal segment 3—contraction ascending.
3. Time 1/10 second.

Record VI. Relation between abdominal movements and the forward movement of the head and pronotum. Dyspnea.

Traces: 1. Head and Pronotum—Lower line normal, upper line duration of forward movement.
2. Time 1/10 second.
3. Abdominal segment 3—contraction ascending.

Record VII. Pressure changes in the tracheal system and their relation to the abdominal movement.

Traces: 1. Time 1 second.
2. Manometer indicator—pressure increase ascending.
3. Abdominal segment 3—contraction descending.

Record VIII. Pressure changes in the tracheal system and their relation to the abdominal movement. Hyperpnea.

Traces: 1. Manometer indicator—pressure increase ascending.
2. Time 1 second.
3. Abdominal segment 3—contraction descending.

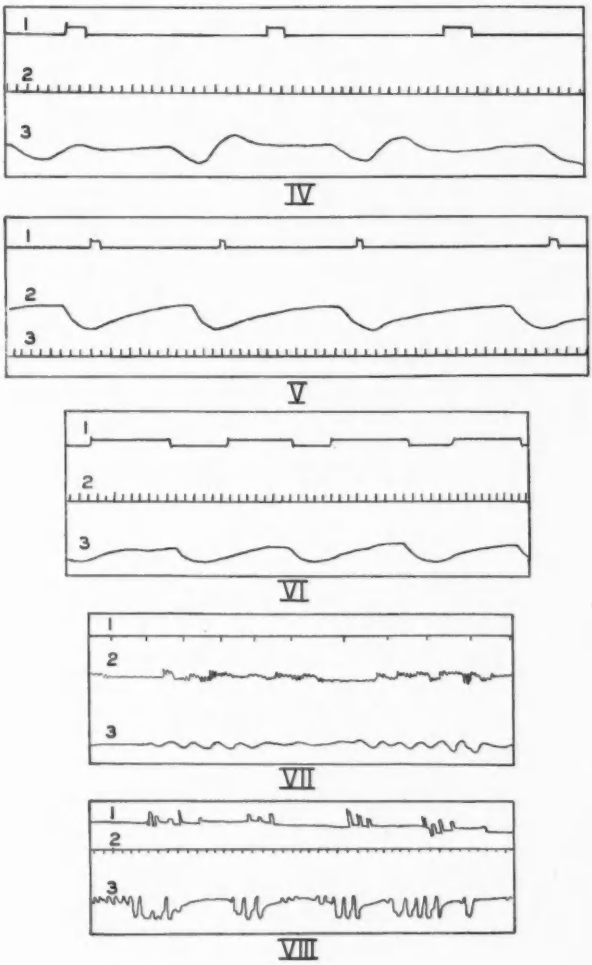

Fig. 7. Tracings of Kymograph Records.
All records read from left to right.

the hemocoel like that caused by a contraction or expansion of the abdomen. During maximum respiratory activity the pressure and volume undergo a cumulative effect, indicated by the removal of the drop from the tube.

For recording pressure changes a small indicator drop of mineral oil was used. At the distal end of the tube a large drop was placed. In this manner the slight as well as the more violent changes could be recorded. The distal drop of oil offered such resistance that its slight response together with the air column between it and the indicator drop served to cushion the more violent movements and prevent the indicator from being removed. At the same time response to slight changes was permitted. The object of these records was (a) to demonstrate that an appreciable pressure is created within the tracheal system and (b) to show how the pressure changes are related to the abdominal movements.

Records VII and VIII, fig. 7, were made during the recovery of a specimen from violent dyspnea. Record VII shows that pressure changes follow the general trend of the respiratory movements. The contractions are accompanied by pressure increases, and the two are proportional in magnitude. The waviness of the pressure line indicates that secondary pressure adjustments occur within the system. During the pauses in respiratory movements the pressure does not rest at the minimum. The pause follows an inspiration, and the pressure is held at an intermediate point. On this record (Record VII) the cycle immediately following each pause is a normal one. When compared to the compression phase it clearly indicates the ineffectiveness of the expiratory movement proper in creating pressure.

The maximum abdominal respiratory movements were so violent and irregular in their effects upon the pressure that the movement of the indicator was unusually difficult to follow. A lag in the pressure line resulted from this difficulty. Sufficient records were made to minimize this, but the reaction time of the observer was a limiting factor. It can be approximately adjusted, however, because pressure maximums and contraction maximums probably are concurrent. It is evident at the beginning of Record VIII that slight inspiratory and expiratory movements are not effective in the creation of pressure. Each of the pauses on the record is followed by the phases of one normal cycle and then a series of dyspneic cycles; a comparison of effectiveness is again shown. This record indicates a readjustment of the ordinary dyspneic cycle to extreme conditions. A combination with the normal cycle occurs. A series of normal inspiratory and expiratory movements with no intervening compression is followed by a series of dyspneic cycles. From the viewpoint of the principle for respiration advanced earlier in this paper, the first part of this series of movements aerates the peripheral region of the system; the latter parts accommodate the more remote regions.

In order to estimate the pressures which had created the preceding movements of the indicator, the tube was removed from the grasshopper and connected to pressure pump and mercury manometer. Sufficient pressure was applied to simulate the movements of the indicator during the experiment. It was evident that the pressure rise and fall was exceedingly abrupt. Because of the limitations of the apparatus (the

deficiencies of which would give results below the actual pressure) it seems apparent that in a system of such small capacity a considerable pressure must be exerted to impress itself upon such a comparatively gross indicator. The results (Table I) indicate that an appreciable pressure is produced in the tracheal system of these insects.

Table I

Pressures in Mm. of Mercury

Normal respiration	2
Dyspnea	7
Maximum	30

DeMoll (1927) reported that the pressure within the tracheal system of May beetles increased less than 0.5 mm. during expiration. In grasshopper respiration the pressure at expiration is not the maximum pressure.

Discussion.—The results of these observations on pressure changes support the inferences drawn from the preceding studies of mechanical correlations. During normal respiration the inspiratory and expiratory phases were accompanied by comparatively slight pressure changes in the tracheae. The compression phase was accompanied by a distinct increase in pressure, as would be expected. Compression during dyspnea was indicated by the fact that the pressure mounted and fell abruptly, though it had previously been shown that expiratory valves were open during the maximum part of the contraction.

CONCLUSIONS

1. The spiracular valves are properly related mechanically to the abdominal respiratory movements to function as inspiratory and expiratory spiracles as defined by Lee (1925).

2. There are three distinct phases in the normal respiratory cycle. These are inspiratory, compressatory, and expiratory.

3. A compressatory phase is an integral part of the respiratory cycle.

4. There are two mechanically different types of breathing—the normal cycle and the dyspneic cycle. This is a modification in the mechanism which results from increased respiratory demands. Dyspnea causes a merging of the expiratory and compressatory movements of the abdomen so that mechanically only two phases appear in each cycle. The functional results are the same as in normal respiration. A third variation in the cycle may occur. A series of simple inspiratory and expiratory phases, with no compressatory phase intervening, may be followed by a series of the deep dyspneic cycles. This last series is often followed in turn by a pause ending with a normal cycle and a series of dyspneic cycles.

5. The fluctuations of the air sacs do not correspond uniformly to the abdominal movements but show a decided lag in the more remote regions of the tracheal system. A delay in the pressure changes in these regions is indicated by this condition.

6. It is suggested that the air sacs permit the building up and retention of a sufficient pressure to supply air to the more minute tracheae. They allow the translation of hemocoelomic pressure into differential intratracheal pressure. This is the result of their collapsibility and diminishing size along the tracheal system. The exchange of air at the remote parts of the tracheal system is thought to occur at a considerably higher pressure level than at the spiracles.

7. The respiratory mechanism is such that the quantity of air and the pressure can be increased in the tracheal system when demand for increased oxidation occurs.

8. Dyspnea not only increases the volume and frequency of the exchange of air but it also increases the pressure exerted.

9. The intratracheal pressure is increased by general body movements, by the feeding movements, and possibly by the presence of food in the digestive tract.

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AN INTRODUCTION TO GENETICS, by A. H. STURTEVANT and G. W. BEADLE. 12 mo. of 391 pages with 126 figures. 1939. Published by W. B. SAUNDERS Co., Philadelphia. Cloth, $3.25.

This is the first text on heredity to come from the hands of the Drosophila geneticists and it deviates from other available texts in ways which might be expected from this fact. Emphasis is mainly on the theoretical aspects of genetics—the nature of the gene and the detailed behavior of chromosomes. Large sections of the book are devoted to chromosomal changes, their genetic consequences and their significance in evolution. The examples are apparently drawn from Drosophila whenever possible, although almost every material that has been used in genetic experimentation receives mention in some part of the book. Most of the hereditary traits which are mentioned are used solely for the purpose of illustrating some point in genetic theory; few are mentioned in any organism because of their interest *per se*. The writing itself is clear, concise, authoritative, but not particularly vigorous.

An Introduction to Genetics is especially recommended as a text for elementary genetics courses which are designed to give the student a thorough and technical background for advanced study and research in genetic problems. By a careful reading of the book and working of the numerous problems offered at the ends of the chapters the student should gain a more thorough mastery of fundamental genetics than could perhaps be acquired through any other elementary text. For less specialized students, however, the book is less well suited. There are no sections on the more practical and more speculative fields of human genetics, eugenics, or plant and animal breeding, and the sections on population genetics, on inbreeding, selection, etc., are not very full. There is a conspicuous lack of material which would make the study of genetics of maximum interest to the general college student.

The chapter titles are as follows: Sex Chromosomes—Sexlinkage—Autosomal Inheritance—Independent Assortment—Linkage—Chromosome Maps—Relation of Crossing Over to Meiosis—Inversions—Incomplete Chromosomes—Lethals—Translocations—Multiple Alleles—Mutations—Position Effect—Non-disjunction and Related Phenomena—The Determination and Differentiation of Sex—Overlapping Phenotypes, Selection, and Hybrid Vigor—Heterogeneous Populations—Polyploidy—Species Differences—Extrachromosomal Inheritance and Maternal Influences—Genes and Phenotypes—Historical—Appendix.

The appendix on Probability includes a discussion of the Binomial and Normal distributions. It is rather surprising to find that the Chi-square statistic is not mentioned here, since it is perhaps more easily understood, more easily calculated, and certainly of wider applicability than the alternative methods which receive discussion.—C. W. C.

THE EARLY EMBRYOLOGY OF PRODENIA ERIDANIA

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The moth, *Prodenia eridania*[1], belongs to the family Noctuidae. Its larva is known as the "Southern Army-worm," and like many others of its family is of considerable economic importance as it feeds on many succulent truck and ornamental plants, chiefly in the Gulf States. Since it is easily reared and is representative of such a large group of economically important Lepidopterous insects, it is being increasingly used for physiological and toxicological research in the government laboratories.

Considerable work has been done on the embryology of the Lepidoptera (Drummond 1936, Eastham 1927 and 1930, Ganin 1869, Hatschek 1877, Hanson 1932, Hirschler 1906 and 1924, Huie 1918, Johannsen 1929, Saito 1934, Schwangart 1904, Schwartz 1899, Seiler 1914, Snodgrass 1935, Strindberg 1915, Toyama 1902, Woodworth 1889), but no complete account of the development of any member of the family Noctuidae has been published. Since developmental processes among insects are so diverse (Imms 1925, Korschelt and Heider 1899, Richards 1932) and since, also, the embryological work on other related families is so incomplete, with the exception of the work on *Pieris* (Eastham), comparisons based on analogy would be unsound and of little value. For these reasons, a critical investigation of the embryological development of *Prodenia* has been undertaken and the early phases, i. e., from egg laying to mid-gut formation, are considered in the present paper.

MATERIALS AND METHODS

Eggs of the moth were obtained from the Division of Control Investigations, Bureau of Entomology and Plant Quarantine, at Beltsville, Md. They were shipped on pieces of wax paper, upon which they had been laid, rolled up in damp cotton and enclosed in a short mailing tube. Thus packed, they arrived uninjured and with viability apparently unaffected.

[1]The authors wish to express their sincere appreciation to Dr. J. F. Yeager of the U. S. Bureau of Entomology and Plant Quarantine, at Beltsville, Md., for furnishing material and laboratory facilities for a short period when the work could not be carried on in New York.

The larvae which hatched from these were reared in battery jars and fed on lettuce and spinach. As described by Babers (1938), the larvae are subject to infection by the soil organism *Bacillus cereus*. To control infection by this or other organisms it was necessary to clean the rearing jars and transfer the animals to fresh food daily.

Both larvae and pupae were kept in a constant temperature incubator at 26° C.

Since the larvae normally burrow in the soil to pupate, they were supplied with a layer of moist sand in the bottom of the battery jars. A number of larvae, which had shown their disposition to pupate by burrowing, were removed from the sand and transferred to clean vials so that casting of the last larval skin and emergence of the moth could be observed. By this means it was found that the pupal period, at a temperature of 26° C., lasted for 8½ to 9 days.

Copulation was not observed. Oviposition did not take place under the imposed laboratory conditions until at least three days after emergence. The moth is nocturnal in habit and deposits its eggs only in the dark. Even under laboratory controlled conditions of continuous darkness it has a preference for ovipositing between the hours of 9:00 P. M. and 1:00 A. M.

Since females ceased laying when disturbed, or in any prolonged period of light, accurate timing was difficult. At intervals of fifteen minutes or half an hour, the new egg masses were observed during a brief period of illumination, and the relative position of these to earlier masses mapped on a sheet of record paper. When it was desired to secure eggs for the very early stages of development with approximately accurate timing, a female actively laying was isolated and the time of deposition of her last eggs recorded. It was thus possible to secure a group of eggs known to have been deposited within a period of 10 to 15 minutes.

Taking a suggestion from the work of Mansion (1926), actively ovipositing females were removed from the cage and decapitated. These beheaded animals, either spontaneously or on mechanical irritation of the abdomen, continued to lay in the light under direct observation, and the eggs could be immediately fixed. In this manner the earliest stages were secured, accurately timed to the minute.

The moths prefer fresh leaves as a substrate for their eggs, but in the absence of these will deposit on wax paper. Because it will not curl or shrink, wax paper is preferred for easy handling of the eggs.

The eggs are covered with a sparse layer of down or fine scales from the genital plates of the female. This thatch of downy scales is hydrophobic and had to be brushed from the upper surface of the egg mass with a fine camels hair brush to allow the fixative to come into contact with the egg surfaces. If this precaution was not taken, the egg surface was protected from the fixative by an enclosed layer of air. While still on the substrate, each egg mass was cut into several groups, each to be kept for different periods of development before fixation. Eggs were not removed from the bit of wax paper or leaf until ready for clearing.

The material was fixed in Kahle's formol-alcohol-acetic. All members of a group of eggs were either punctured with a sharp, steel needle

and quickly covered with the fluid or first submerged and then punctured. During dehydration they were stained with eosin in the 95% alcohol to insure visibility when later embedded. In the absolute alcohol they were removed from the substrate and cleared in xylol, a process which was necessarily very gradual, to prevent serious shrinkage. Transference into the paraffin was also graded.

A large drop of hot paraffin was placed on a glass slide under a binocular dissection microscope and infiltrated eggs were transferred into it with a warm pipette. Before the paraffin solidified they were oriented in a row within it with a flame-warmed needle. Thus oriented, several eggs in one paraffin "button" could be consecutively cut in one ribbon. The slide upon which this button was made first had to be covered with a film of glycerine to prevent the paraffin from adhering to the glass.

Sections were cut at 8 micra and stained in Heidenhein's Iron Haematoxylin or Delafield's Haematoxylin and counterstained with eosin. All drawings for illustration were made with the use of a camera lucida.

In order to determine the distance relationships of cleavage nuclei, topographical drawings of projected serial sections were made. It was found satisfactory and extremely simple to make projections by placing an ordinary microscope and microscope lamp below a support on which rested a plain piece of glass. The projected image could be focused sharply on white paper lying on this glass, and the features desired outlined quickly in serial order. Sections of embryos were projected in this manner onto a thin, transparent paper. These drawings were traced onto wax mats of the desired thickness made of paper towelling soaked in paraffin (58° to 60° C.). The drawings on the mats were cut out and fitted together into reconstructions of the embryo. A model of this type, though roughly constructed, was an invaluable aid in understanding the process of blastokinesis and the position relationships of layers and organs during developmental activity.

DESCRIPTION OF THE EGG

The egg is subglobular in form, showing a slight flattening at the upper pole and a greater flattening of the lower surface when it is in contact with the substrate. Its equatorial diameter ranges from .45 mm. to .55 mm. The color of the egg, which is imparted to it by the yolk, ranges from pale greenish-yellow to bright green. Its color is the same by both transmitted and reflected light. Differences in color are not found in eggs of the same laying, but are exhibited in masses deposited by different females.

The egg is covered by a soft, translucent, and reticularly sculptured chorion. The sculpturing is presumably determined by the follicular cells in the ovary and consists of numerous shallow, elongate, depressed areas separated by sharp ridges. In the equatorial region the depressions are largest, becoming progressively smaller toward the upper pole where the ridges converge. The micropyle is located at the upper pole and the lines of sculpturing spread radially from it. It consists of a

single small hole around which the chorion is somewhat raised and thickened to form a small funnel (fig. 2). The lower part of this funnel is strengthened by three radially projecting thicknesses of the chorion. In all sections of fertilized eggs the micropyle is closed by a delicate membrane which appears to be an integral part of the chorion. No hydropyle appears in the chorion and if moisture is absorbed at any particular point in the surface during development the micropyle probably assumes this function.

INTERNAL STRUCTURE OF THE EGG

At oviposition the egg is made up internally of a large central yolk mass, surrounded by a relatively thin cortical ooplasm (fig. 1, c. o.), which is in turn covered by the vitelline membrane, (fig. 1, v. m.).

The central yolk mass consists chiefly of non-staining globules interspersed with a few small, basophilic globules supported in a cytoplasmic reticulum (fig. 1, ret.). The strands of this reticulum appear to be continuous with the cortical ooplasm. Equidistant from the center toward the egg boundary the inner "core" of yolk is marked off by a region containing a greater concentration of numerous, deeply basophilic spherules (fig. 1, ba. sp.). This region encompasses the "central core" of the egg and lies about midway in the yolk between the egg center and the surface. In sections it appears as an outwardly arched band tapering off as it approaches the poles. This differentiation of the yolk appears to be constant for fertilized, prezygotic eggs.

The cortical ooplasm (keimhautblastem; peripheral protoplasm, etc.) is a differentiated layer of protoplasm evenly covering the entire surface of the yolk. It is divided into two layers. The thicker of these, the inner layer, averages 10 micra in depth. It is of a homogeneous or uniform consistency, being unvacuolated and finely but densely granulated. The outer, thinner layer has a spongy appearance (fig. 1 and 2, c. o.). It is packed with numerous, small, irregularly shaped vacuoles. The inner layer has the greater affinity for stain.

The vitelline membrane is very thin and adheres closely to the cortical ooplasm. In those sections where it became partially separated from the surface of the egg it shows no regularity of structure but possesses irregularly spaced and sized granular thickenings. Other than the possession of these granules the vitelline membrane appears structureless.

At oviposition the germinal vesicle is in metaphase or anaphase of the first maturation division. It lies in a small, hemispherical, inward expansion of the cortical ooplasm, (richtungsplasm, polar plasm) in the upper half of the egg, at a constant distance of about 50 degrees from the micropyle (figs. 1 and 4, r. p.). The sperm lies in a small cytoplasmic island in the yolk just beneath the micropyle (fig. 1, sp.). Later it shortens, condenses (fig. 3, sp.), and forms a pronucleus which remains in this position until the female pronucleus fuses with it.

From the germinal vesicle are derived three polar bodies (fig. 4, p. b.) and the female pronucleus which migrates to the position of the sperm nucleus where fertilization takes place (fig. 5, z. n.).

CLEAVAGE

About one hour after oviposition, the zygote nucleus divides. A series of synchronous divisions follows. The mitotic figures are oval in shape and possess definite centrioles and spindle fibers (fig. 7, cen. and sp.).

At approximately the time when four cleavage nuclei are present in the egg, the polar bodies fuse into a single vesicle located centrally in the richtungsplasma (fig. 6, p. b.). At the time of fusion their chromosomes are prominent and distinct, but gradually they merge into large, irregular, chromatic strands. These chromatic strands seem to attempt an unsuccessful division within the vesicle and persist prominently in the cortical ooplasmic bulge until the cleavage nuclei move to a position just beneath the cortical ooplasm. At this point they quite suddenly disappear. Not only are all traces of the polar bodies lost but also the cytoplasmic mass in which they were located. Thus no trace of their position in the egg remains to indicate whether or not the polar bodies have any function in the subsequent organization of the germ band. Because of the radial symmetry of the egg, their position cannot be correlated with any later point on the blastoderm. Reconstructive drawings of cleavage nuclei within the egg gave no indication that the polar body area had any influence on the migration of the nuclei.

From the position of the zygotic nucleus just beneath the micropyle, the cleavage nuclei, (fig. 8, cl. nu.), as they divide, spread out into a roughly spherical, hollow configuration. They have a definite and apparently digestive action on the yolk. As they progress peripherally, the yolk within the area they enclose loses its vesicular appearance, due perhaps to the loss of cytoplasm. The colorless yolk bodies become smaller and more rotund and a larger number of deeply basophilic globules appear. This distinction is very evident in the 256 nuclei stage when the cleavage nuclei are close to the cortical ooplasm and beginning to enter it. At this point the nuclei are very definitely aligned in a hollow, subspherical arrangement (fig. 8). Nuclei were observed to enter the cortical ooplasm first at the ventral pole of the egg.

About four hours after oviposition, all the future blastoderm nuclei have entered the cortical ooplasm. Certain cleavage nuclei which lag behind in the advancement to the periphery, and a few others apparently late in arriving at the cortical ooplasm, fail to enter it. These nuclei remain in the yolk as vitellophags (fig. 9, vit.). Vitellophags were never observed undergoing division. They remain with larger and more basophilic nuclei than the blastoderm and subsequent embryo cells. Though no counts were made, the number of vitellophags in various eggs did not appear to be constant.

BLASTODERM, SEROSA AND AMNION FORMATION

The migrating cleavage nuclei enter the cortical ooplasm first in the ventral floor of the egg. From that point progressively around the egg they enter it and thus form a syncytial blastoderm. This syncitium is uniform in its distribution of nuclei throughout. Invaginations from the surface now progress gradually inwards between these nuclei, and when they have reached almost to the base of the blastoderm, they

spread laterally. In this manner the nuclei, each with its surrounding cytoplasm, are incorporated in separate cells. At the completion of this process the blastoderm is a uniform layer of rather large, mononucleate cells (fig. 9, bl.). Below it and separating it from the yolk lies a basement membrane (b. m.) made up of cytoplasm which formerly surrounded the migrating nuclei but which was excluded when the invaginations separated the nuclei during cell formation.

As described by Johannsen (1929) in *Diacrisia*, the cells of the blastoderm, in an area surrounding each pole of the egg and connected by a narrow meridional isthmus, now divide. Nuclear division in this area continues, accompanied by only partial cytoplasmic division, with the result that there is soon marked off a "dumb-bell" shaped area of polynucleate cells (fig. 10, p. s. c.). This is the future serosa. Because of the shape of this extra-embryonic region, the remainder of the blastoderm exists as a broad equatorial band whose anterior and posterior ends are separated by only the narrow meridional isthmus of extraembryonic cells. The cells of this broad, equatorial, germ band undergo mitotic divisions throughout and become more compact and columnar in structure.

The distinction between the two regions having become fully established, the extraembryonic cells (serosa) spread laterally over the outer surfaces of the germ band (fig. 10, g. b.). From this point on, serosa cells were never observed to divide. The serosa is formed by a lateral spreading and axial thinning of these large polynucleate cells. During the process of development, the cytoplasm of these cells is constricted, forming cell walls, so that the serosa, when complete, is made up of mononucleate, squamous cells. At the age of nine hours, the serosa completely encloses the germ band and yolk (fig. 11, s.).

At about the time when the serosa is completely formed, the edges of the germ band curl outwards (figs. 11 and 12). Cells from these curled edges spread across the outward or ventral face of the germ band to form a distinct membrane, the amnion (a.). The amnion forms before any blastokinesis occurs, and while the ventral surface of the germ band lies against the serosa. Thus the amnion prevents the ventral surface of the germ band from ever coming in contact with the yolk (fig. 18). Amnion formation is complete in from sixteen to eighteen hours. The germ band at this point lies curled laterally around the egg. Its ventral surface is covered by the amnion and the serosa and its dorsal or inner surface is in contact with the yolk.

BLASTOKINESIS

During serosa and amnion formation, by a series of asynchronous divisions, the germ band becomes a compact single layer of highly columnar cells (fig. 11, g. b.). It undergoes a slight lateral shrinkage thus becoming narrower throughout its entire length. This lateral shrinkage is probably due to both cytoplasmic contraction throughout and to amnion formation. Cytoplasmic contraction is suggested by the fact that the germ band is now very compact, whereas the blastoderm from which it arose was rather loosely constructed (figs. 9 and 11, g. b.).

About the time of the completion of the amnion (sixteen to eighteen hours) the anterior end of the germ band curls into the yolk and broad-

ens. Localized areas of mitotic activity on either side of the midline result in two antero-lateral, outward bulges or cephalic lobes.

The mid-region of the germ band undergoes a still greater lateral shrinkage. The posterior end of the germ band curls sharply into the yolk to form a caudal pouch. Accompanying this change in form, there is a small increase in length and the germ band twists slightly so that the anterior end or head is somewhat higher and nearer the upper pole than the caudal end.

MESODERM FORMATION

At the end of approximately fourteen hours, before the germ band has changed in form, cells in its midline become active. Beginning near the anterior end of the embryo at a point which eventually will lie between the future cephalic lobes, and extending to a point near the caudal end, which later coincides with the point of greatest caudal flexure, this activity gradually progresses. The cytological expression of this activity is the elongation of the midline cells and the vacuolization and lateral expansion of their inner ends (fig. 13, m. c.). Accompanying these cytologic changes, this strip of cells invaginates slightly to form a shallow groove along the mid-ventral line. Probably the expansion of the inner vacuolated ends of these cells causes them to bulge inward and thus initiate the infolding process. Subsequent to the invagination of this strip of cells there follows a proliferation from it, perhaps of a few cells, but notably of cellular material in the form of eosinophilic globules and fragments. These pass into the yolk and disintegrate. The chief result of this proliferation is to establish a now distinctly differentiated middle plate in the germ band (fig. 14, m. p.). The middle plate has lost its former thickness and is a thin layer of cuboidal cells. The lateral plates which have increased in thickness now seem to press it between them and spread over it (fig. 15, l. p.)

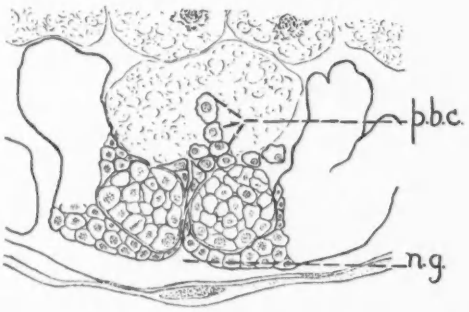
Simultaneously with the differentiation of the middle plate, the yolk, formerly a homogeneous undivided mass, is divided into separate compartments or yolk cells (compare fig. 9 and 11 with 14 and 15, y. c.). Each of these spherules possesses one or more nuclei, the former vitellophags, and is surrounded by a definite membrane. It may be that the extruded cellular products from the middle plate cells have some bearing on this division of the yolk.

As the middle plate is pressed inward between the lateral plates, there follows a second inward proliferation from it. This proliferation is not continuous, but occurs segmentally and progresses anteroposteriorly down its length. Each proliferation consists of definite masses of cells which will eventually be pressed against the yolk and form a mesodermal somite (fig. 16, f. m. s.). Continued overgrowth by the lateral plates forces the invaginated middle plate, with its segmentally proliferated cell masses, against the yolk where it spreads laterally. There is thus developed a germ band of two definite layers, the ectoderm and the mesoderm (fig. 17). The division between the lateral plates deepens and is maintained for some time as the neural groove. Segmentation of the ectoderm follows the establishment of this segmented mesoderm.

ENDODERM FORMATION

The most anterior mesodermal mass, or "anterior mesenteron rudiment," which is laid down at a point just back of and between the cephalic lobes, is quite prominent. It is proliferated by a group of cells of the middle plate which maintain their connection with the ventral surface (fig. 18, a. m. r.). As in *Pieris* (Eastham 1927), the lateral plates fail to overgrow completely the middle plate at this point, which in all probability marks the level at which the future stomodaeum invaginates (fig. 18, p. v. c.). The stomodaeal invagination occurs at about twenty-six hours of age and after the ectoderm is completely segmented. As the infolding progresses it parts the mass of the anterior mesenteron rudiment. Thus this ectodermal invagination is surrounded by a layer of mesoderm (fig. 19, stom.). In later stages, as the stomodaeal invagination progresses posteriorly, the mesoderm surrounds it.

The most posterior mass of mesoderm derived from the middle plate lies in the curve of the greatest caudal flexure. This is the so-called "posterior mesenteron rudiment." A few cells in the midline of the



Text Fig. 1. Transverse section of the same embryo in the mid-region of the body showing further proliferation from the midline. N. g., neural groove; p. b. c., primitive blood cells.

ectoderm near the posterior end of the germ band and just posterior to the mesoderm invaginate to form a deep, elongate pouch, the proctodaeum (Fig. 20, proct.). The proctodaeum progresses anteriorly, close against the ventral surface of this mass. Thus as the "mesenteron rudiment" spreads laterally it completely envelopes the proctodaeum (fig. 21, p. m. r.) and spreads over its anterior or blind end in a thin sheet.

As the stomodaeum grows backward, tissue from the anterior endoderm rudiment develops chiefly along its dorsal surface, but cells from this mass grow close to its ventral side and mesoderm, in a thin layer, covers its blind end. At about 50 hours of age chains of cells arising in the mesodermal covering of the stomodaeum, just ventral and anterior to the end of this invagination, progress backward on either side. These chains of cells form the first rudiments of the midgut or endoderm.

Early formation of endodermal strands from mesoderm surrounding the proctodaeum was not observed, but slides of embryos in which the midgut was well-formed showed the endoderm to be continuous with mesoderm surrounding the proctodaeum.

During the early development of the mesenteron, the midline of the embryo is very active in the proliferation of cells. This is particularly true in the cephalic region just beneath the stomodaeum (fig. 22). This proliferation is not as great further posteriorly, but is definitely continuous over the entire midline (text fig. 1). No cytologic resemblance could be seen between these proliferated cells and those of the endoderm, nor was there any evidence that they contributed to its formation.

These cells are primitive blood cells (Eastham 1930) or, as suggested by Snodgrass (1935), endodermal phagocytes. According to the latter author they are representative of the fragmentary remnant of an intermediate mesenteron rudiment and proliferation of these cells represents the final stage of gastrulation.

SUMMARY

The development of the egg of *Prodenia eridania* from oviposition to the completion of gastrulation has been described, including the details of histological structure at various stages.

The egg is subglobular in shape, covered by a soft sculptured chorion and it possesses a dorsal micropyle.

The yolk mass is supported by a cytoplasmic reticulum which is continuous with the cortical ooplasm surrounding it. The yolk is not homogeneous throughout but is differentiated into two concentric layers.

Fertilization occurs within the yolk just below the micropyle. The subsequent formation of cleavage nuclei is in the form of a hollow sphere. Migration of these nuclei through the yolk is accompanied by a loss of the cytoplasmic reticulum. Cleavage nuclei first enter the cortical ooplasm in the ventral region of the egg opposite the micropyle.

The blastoderm is entire but is soon differentiated into an equatorial germ band and a meridional, "dumb-bell" shaped extra-embryonic region which gives rise to the serosa. The amnion is proliferated from the edges of the germ band.

Two waves of proliferation pass down the midline of the germ band; the first differentiation the middle plate and coinciding with yolk cell formation, the second giving rise to the mesoderm.

Endoderm arises from anterior and posterior masses of cells proliferated in the midline in the region of the stomodaeal and proctodaeal invaginations.

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EXPLANATION OF PLATES

Plate I

1. Meridional section through the egg in the plane of the germinal vesicle at the time of oviposition. Chorion not shown. Composite drawing made with aid of camera lucida. Ba. sp., basophilic spherules; c. o., cortical ooplasm; ret., reticulum; r. p., richtungsplasma; sp., sperm; v. m., vitelline membrane.

2. Drawing of section through center of micropyle. Chorion lifted from the egg surface due to fixation. Egg at oviposition. C. o., cortical ooplasm; r. t. radial thickenings.

3. Sperm, 25 minutes after ovipositon. Sp., sperm.

4. Photograph showing one and a portion of a second polar body within the polar plasmic mass. Age, 35 minutes. P. b., polar body; r. p., richtungsplasma.

5. Zygote nucleus just below micropyle (not shown). Age, 35 minutes. P. m., point on surface of egg formerly occupied by micropyle; z. n., zygote nucleus.

6. Fused polar bodies in polar plasma. Age, 1 hour 35 minutes. Ch., chorion; p. b., polar bodies; r. p., richtungsplasma.

Plate II

7. Cleavage nucleus in metaphase. Cen., centriole; sp., spindle.

8. Composite drawing made with aid of camera lucida to show the arrangement of nuclei and differentiation of the yolk in 256 nuclei stage. Age, 3½ hours. Cl. nu., cleavage nucleus.

9. Section through an egg following cytoplasmic division of the blastoderm. Age, 9 hours. B. m., basement membrane; bl., blastoderm; vit., vitellophag.

10. Section through extraembryonic and germ band tissue showing the initial encroachment of the polynuclear serosa cells over the germ band. Age, 12 hours. G. b., germ band; p. s. c., polynucleate serosa cells.

Plate III

11. Section through the egg at the completion of serosa formation and beginning of amnion formation. Age, 14 hours. A., amnion; g. b., germ band; s., serosa.

12. Transverse section of the germ band during early amnion formation. Age, 14 hours. A., amnion; g. b., germ band; s., serosa.

13. First proliferation and invagination in the midline of the germ band. Transverse section of the germ band. Age, about 18 hours. M. c., cells of the midline.

14. Transverse section through the germ band showing the middle plate. Age, 18 hours. L. p., lateral plate; m. p., middle plate; y. c., yolk cell.

Plate IV

15. Same, showing the middle plate pressed inward by lateral plates. Same embryo as above but further anteriorly in it. L. p., lateral plate; m. p., middle plate; y. c., yolk cell.

16. Oblique section through a cell mass proliferated by the middle plate. Age, 22 hours. F. m. s., future mesodermal somite; y. c., yolk cell.

17. Transverse section of the germ band following deposition of the mesoderm. Age, 26 hours. Ect., ectoderm; mes., mesoderm.

18. Sagittal section through the anterior end of the germ band showing the anterior "mesenteron rudiment." Age, 22 hours. A., amnion; a. m. r., anterior mesenteron rudiment; p. v. c., point of contact with ventral surface.

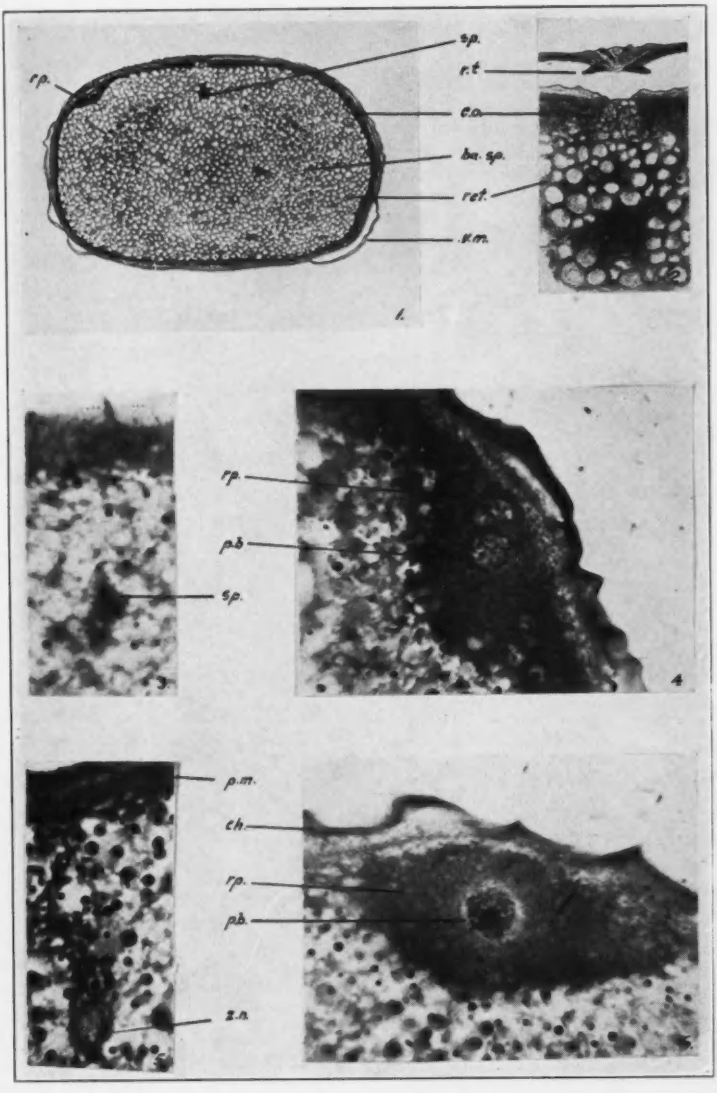
Plate V

19. Sagittal section through the anterior end of the germ band during early stomodaeal invagination. Age, 26 hours. A. m. r., anterior mesenteron rudiment; stom., stomodaeum.

20. Longitudinal section through proctodaeal invagination. Age, 30 hours. P. m. r., posterior mesenteron rudiment; proct., proctodaeum.

21. Transverse section of proctodaeal invagination at this same age. Age, 30 hours. P. m. r., posterior mesenteron rudiment; proct., proctodaeum.

22. Transverse section of stomodaeum a few sections behind the mouth. Age, about 34 hours. P. b. c., primitive blood cells; stom., stomodaeum.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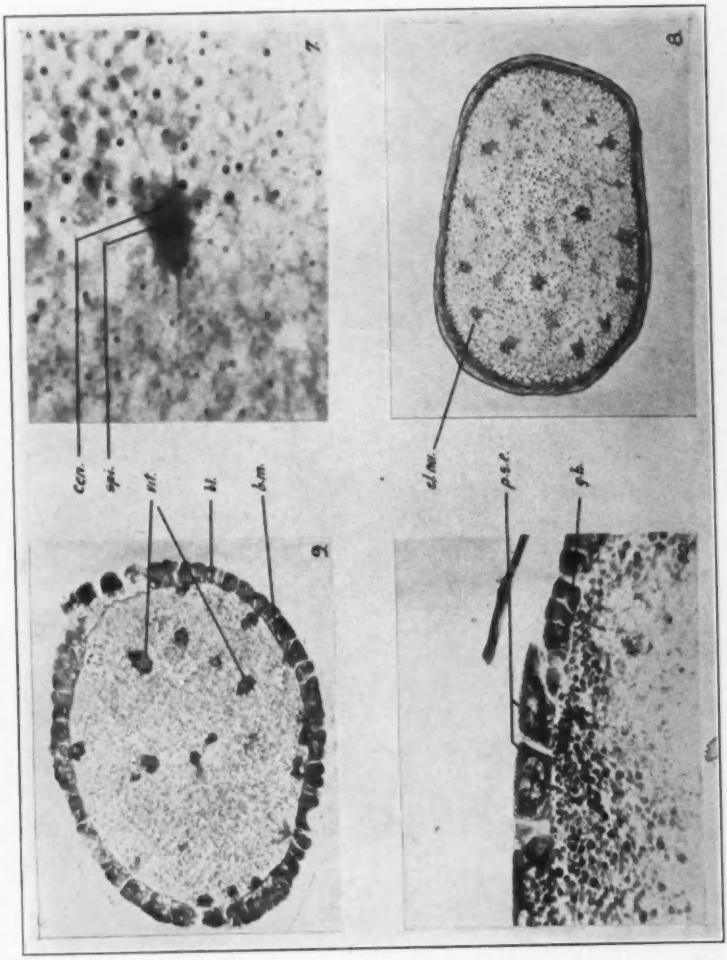
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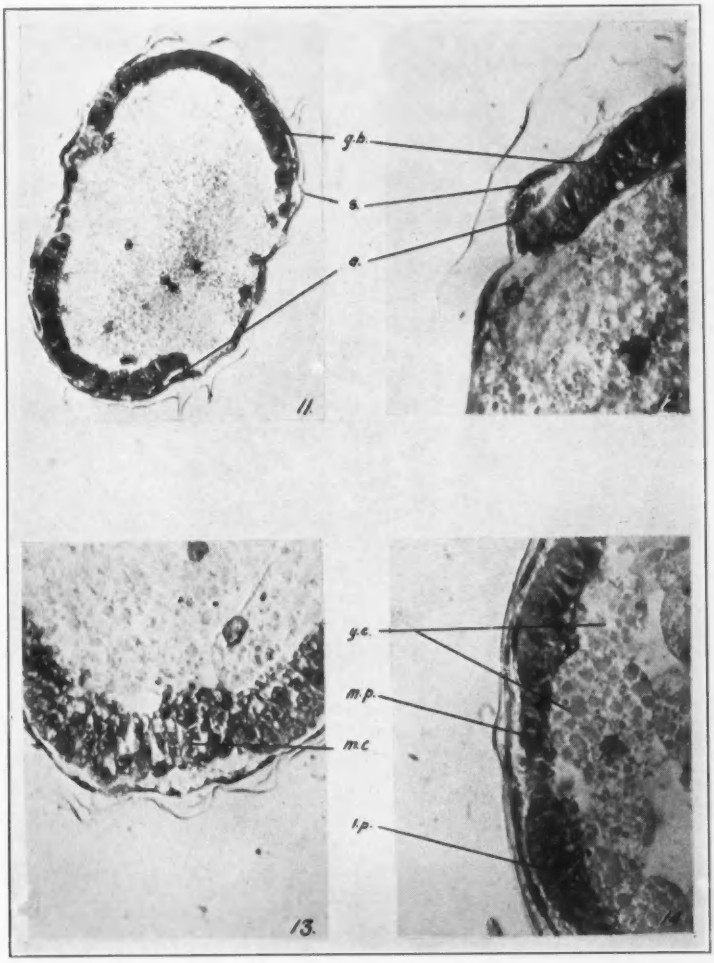
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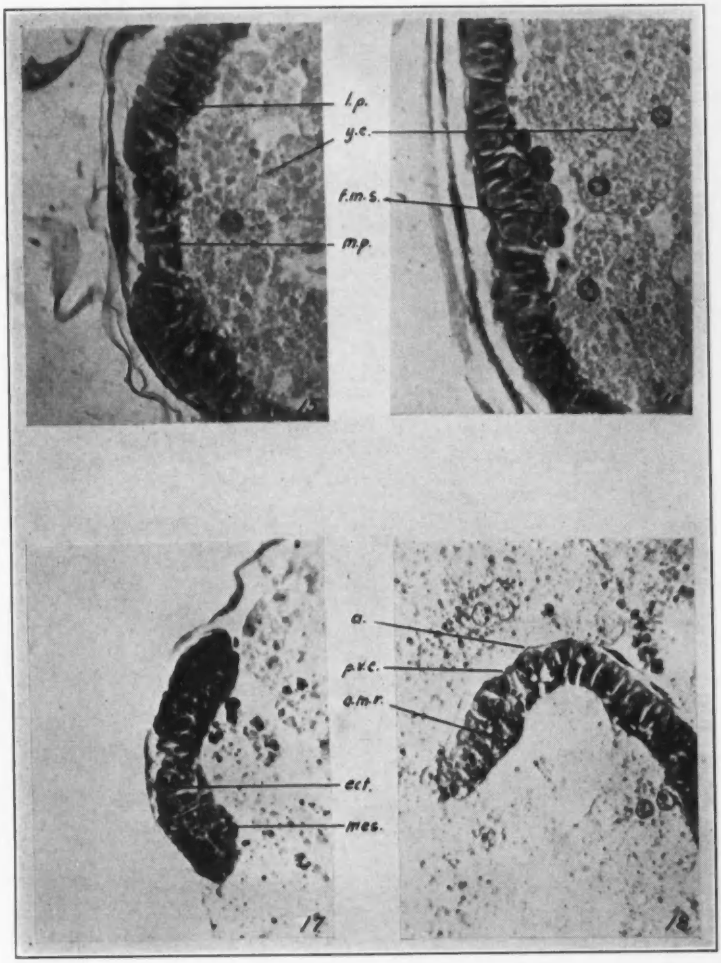
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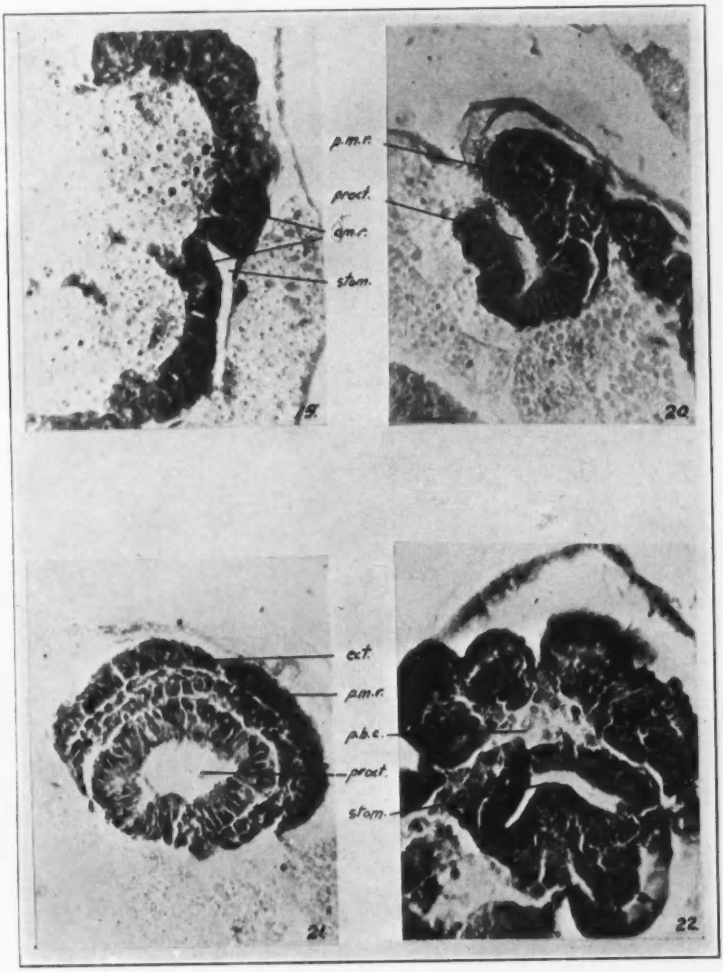
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THREE NEW WESTERN SIMULIIDAE (DIPTERA)[1]

G. S. Stains and G. F. Knowlton[2]
Logan, Utah

Black fly annoyance to livestock has been observed in many localities of Utah; this has led the writers to make a study of the species occurring in this area. The following report deals with three apparently undescribed blood-sucking flies of the family Simuliidae.

Simulium (Simulium) twinni *n. sp.*[3]

Male.—Length 1.64 mm.; wing 2.15 mm. With characters of the sub-genus; radius bare on entire length, radial sector simple. *Head:* black; clypeus gray pollinose. Antennae eleven jointed, black, clothed with yellowish-white pollen. Palpi black, about as long as antennae and with sparse black hair. *Thorax:* black; scutum velvety black with lateral and wide caudal edges silvery pollinose, its entire surface covered with sparse yellow pile; scutellum bare, dark brown and pointed; pleurites silvery pollinose. *Legs:* grayish, covered with long sparse black hairs; mid-and hind-coxae black, fore coxae yellowish; apical fifth of hind femora and tibiae abruptly blackened; apical half of hind and mid-tarsi infuscated; fore femora and tibiae more infuscated near apex; tarsi black; front tibiae silvery pollinose on ventral surface; claws bifid (i. e. with basal tooth); pedisulcus (dorsal incision near the base of the hind second tarsal joint) absent; calcipala (a projection at the apex of the basitarsus projecting beyond the base of the hind second basitarsus) present and distinct. *Wings:* halteres yellow, base merging into black; hairs on base of wing long and pale, elsewhere black. *Abdomen:* velvety black covered with sparse yellow pile; basal fringe black; wide lateral surface of second, sixth and part of seventh segments silvery pollinose. *Genitalia:* adminiculum (fig. F) "saddle" or M-shaped with long divergent arms and possessing a definite central keel-like structure; the inner surface dentate; adminiculum shoulders conspicuously striated; side piece longer than wide; clasper (fig. I) longer than side piece, with a terminal spine and a conspicuous spinose projection near base; adminiculum arms (fig. D) with many large teeth on each side.

Taxonomy: Simulium perissum D.-S., *S. vandalicum* D.-S., *S. turmale* Twinn and *S. jacumbae* D.-S. also possess a spinose projection at base of clasper: *S. twinni* differs from these in adminiculum being distinctly "M"-shaped; adminiculum arms

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[1]Contribution from the Entomology Department, Utah Agricultural Experiment Station.

[2]Graduate assistant and research associate professor of entomology, respectively.

[3]Named in honor of C. R. Twinn.

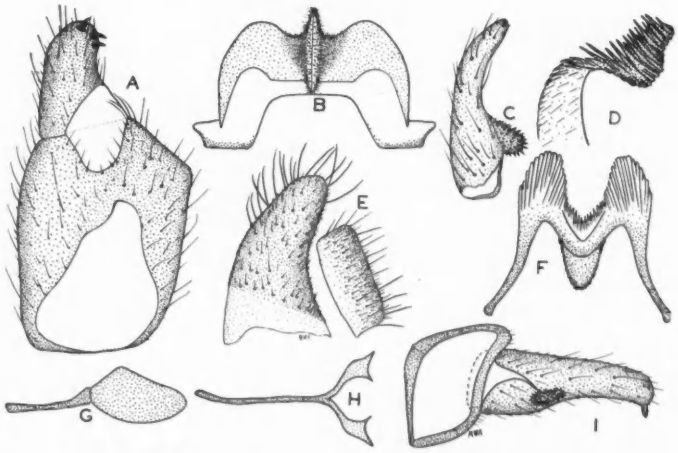
with large teeth and broader at base; side piece being more triangular.

Holotype: male, collected in trap light four miles above mouth of Logan Canyon, Utah, August 8, 1939 (Knowlton).

Paratypes: males, Logan Canyon, Utah, July 17, 1938 (D. E. Hardy-A. T. Hardy); a number of males collected at light in Logan Canyon during the season of 1939 (Knowlton).

Simulium (Eusimulium) hardyi *n. sp.*[4]

Male.—Length 2.5 mm.; wing 3.2 mm. Possessing the characters of the sub-genus. *Head:* black; clypeus black, narrow with long sparse



Simulium (*Eusimulium*) *hardyi* n. sp. Male-A, Side piece and clasper. B, adminiculum; G, spatulate structure. *S.* (*Simulium*) *twinni* n. sp. Male—C, side view of clasper; D, adminiculum arm; F, adminiculum; I, face view of side piece and clasper. *S.* (*Eusimulium*) *flaviantennus* n. sp. Female—E, cerrus and anal lobe; H, genital fork.

yellow pile; palpi black to brownish apically with pile slightly shorter than on the clypeus. Antennae black, eleven jointed, pale pollinose except two basal segments. *Thorax:* black; notum covered with long sparse yellow pile; pleurites bare except the pteropleural membrane which has a tuft of yellow pile near its middle. Scutellum black with pile four times longer than that of the dorsum. *Wings:* hair black, stem vein dark setose; radial sector simple; halteres nearly black. *Legs:* infuscated, darker near joints; femora and coxae with long yellow pile, other leg segments with shorter and darker pile; coxae black; hind

[4]Named in honor of D. Elmo Hardy, former member of this Department.

basitarsi three times longer than wide; pedisulcus absent; calcipala but moderately developed. *Abdomen:* dull black with long black pile; segments reduced apically; basal fringe nearly black. *Genitalia:* clasper (fig. A) short, half as long as side piece, rounded apically with three irregular spines on apex; side piece broad, nearly ovate. Adminiculum (fig. B) broad, concave, with a very prominent keel which is conspicuously setose. Two characteristic spatulate structures are attached to the sides of the adminiculum, (fig. G).

Taxonomy: Simulium hardyi in Dyar and Shannon's Key (Proc. U. S. Nat. Mus. 69 : 13) keys to the group with the stem vein dark pilose. *Simulium hardyi* differs from this group in the pedisulcus being absent; the claspers possessing three terminal spines at apex; the adminiculum with a very conspicuous central keel and spatulate structures attached to the sides.

Holotype: male, Mill Creek Canyon, Utah, June 24, 1938 (Knowlton-D. E. Hardy).

Paratypes: two males, Kanosh Canyon, Utah, May 27, 1939 (Knowlton-F. C. Harmston).

Simulium (Eusimulium) flaviantennus *n. sp.*

Female.—Length 3.2 mm.; wing 3.8 mm. With characters of the sub-genus; radius setose throughout entire length; radial sector simple. Calcipala and pedisulcus absent. *Head:* black; front, vertex, palpi and clypeus and behind the eyes covered with long yellow pile; clypeus black; antennae eleven jointed, yellow, basal and apical segments somewhat black; palpi approximately as long as antennae, black. *Thorax:* black; integument with yellow pile on the notum equal to that on the head; pleurae bare except for a tuft of yellow pile directly above the middle coxae (pteropleural membrane); scutellum brownish with yellow pile, three times as long as that of the dorsum. *Wings:* hairs at the base long, pale, elsewhere black; veins becoming lighter near base; halteres yellowish. *Legs:* yellow, clothed with long yellow hairs except on the tarsi; fore coxae slightly yellowish, mid- and hind-coxae black, all covered with yellow pile; fore and mid-tarsi infuscated, hind tarsi infuscated with apical segments merging into black; hind tibiae darkened at tip; tarsal clews simple. *Abdomen:* black; clothed with thick yellow pile; abdominal segments equal except the basal segment which is nearly twice the usual width.

Genitalia: genital fork (fig. H) with stem approximately three times width between forks; apex of anal lobes rounded with hairs a little longer than those on cerrus; cerrus (fig. E) rectangular with outer margin heavily sclerotized, armed with hairs about equal to width of cerrus.

Taxonomy: differs from *S. frisoni* D.-S. in cerrus distinctly rectangular; genital fork arm bases more slender; apex of anal lobe rounded and possessing longer hairs; ovipositor flaps but

moderately developed. Dyar and Shannon (Proc. U. S. Nat. Mus. 69 : 18, 1927) in their description of *frisoni* gave very few external characters.

Holotype: female, Logan Canyon, Utah, July 10, 1938 (D. E. Hardy-A. T. Hardy).

Paratype: female, Kanosh Canyon, Utah, May 27, 1939 (Knowlton-Harmston).

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In the present condition of our published lists of generic names zoologists are so far from having a complete list that the inventor of a new generic name tries rather to create a name so unusual that the probability of its having been used before is slight, rather than attempt to check his new name through the various partial lists since Waterhouse in 1912.

About 192,000 generic and subgeneric names have been proposed since the system was started in Linnaeus' Systema Naturae, 10th Edition, 1758. The present work adds cross references and alternative spellings that bring the grant total of entries up to 225,000.

"So far as the proportionate representation of the various classes of animals are concerned, the names of the Insecta outnumber the whole of the rest of the Animal Kingdom, and this predominance has become especially marked during the last 40 years. The Mollusca come second, and are followed by the Arachnida. The Crustacea are also a large group, so that it will be realized that the dominance of the Arthropods over the other animals on this planet is complete."

The compilation of the names, each with one or more bibliographic references, was begun in 1935 and completed early in 1939. The project was co-operative but the burden of work fell largely on the staff of the British Museum of Natural History and on that of the Publication Office of the Imperial Institute of Entomology. "The total cost of preparation (of manuscript) which has consisted mainly of the salaries of a special staff and has amounted in all to about £1,800, has been borne by the Zoological Society of London, though the Council of that Society has not felt justified in incurring additional liability with regard to the further cost (printing, binding, distribution) of the work. . . . Important contributions towards the cost of printing the work have been made by the Carnegie Corporation of New York, The Royal Society and a generous anonymous donor." In his introduction Editor Neave gives two and one-half pages of acknowledgements to the many persons who have labored on the Nomenclator.

As a commentator we wish to point out that this very useful tool in the zoological sciences has been made possible through two forces in British zoology, the underwriting by the Zoological Society of London and the hard work of its Editor, Dr. S. A. Neave, Assistant Director, Imperial Institute of Entomology. Four great London libraries figure into the project, those of the British Museum of Natural History, the Imperial Institute of Entomology, the Zoological Society of London and the Royal Entomological Society of London.

By the preparation of this new Nomenclator the Zoological Society has given continuity to the series of laborious compilations of zoological names, the last list of which was No. II of the Index Zoologicus compiled by C. O. Waterhouse and published by the Zoological Society of London in 1912. The Zoological Society has conferred a great favor on zoology in general. The Annals wishes to express for the Entomological Society of America its appreciation of this very useful work.—C. H. K.

THE NESTING HABITS OF SEVERAL SPECIES OF MEXICAN SOCIAL WASPS

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A short automobile trip by Mrs. Rau and myself to Mexico, February 10 to March 3, 1939, afforded the opportunity to make desultory observations on the nesting habits of social and solitary wasps.[1] Of these three weeks, two were spent south of the Rio Grande, and attention was centered upon the regions of the latitude of Mexico City. Explorations were made from time to time along the Pan-American Highway to Mexico City, and short trips from there southwest to Cuernavaca, Taxco and Iguala, and southeast to Orizaba and Cordoba.

It was with a thrill that we passed the marker "Tropic of Cancer" along the mountain road, but even so, we met with no tropical insects, because of the high altitude. However, whenever we dipped down to lower altitudes, such as Valles, S. L. P., 250 feet above sea level; Tamazunchale, S. L. P., 350 feet; Victoria, Tamaulipas, 1,000 feet; Orizaba, Vera Cruz, 4,000 feet; Cordoba, Vera Cruz, 2,800 feet; Iguala, Guerrero, 2,700 feet, or Cuernavaca, Morelos, 4,700 feet, we found wasps. Even though the number of species was not great, yet they were alive and full of interest. Full of interest, I repeat, because we were fortunate to be on hand at the beginning of their season's activities (February) and able to gather data on the resting period of these wasps, the resumption of their work on the old nests or the beginning of new nests.

Polybia occidentalis Olivier. [Bequaert.]
(Pl. I, figs. 7 and 8)

This harmless wasp, whose acquaintance I had first made in Panama, appeared in several localities in Mexico during February. It makes a nest of paper with combs, one below another, attached to the outer walls. It was found always in the low, tropical country. At Valles, about 250 feet above sea level, a specimen was taken on the wing; at Jacala, Hidalgo, a large nest probably 15 inches in length and 9 inches wide at the center was found attached to a dwelling at the height of a man's head. The outside of this nest was completely covered with wasps resting quietly. At Tamazunchale (alt. 350 feet),

[1]A paper on Solitary Wasps will appear later.

two thriving nests were observed, and at Iguala, two nests in early stages of construction were seen.

The nest at Tamazunchale was attached to an iron rod in a filling-station just above the noisy gasoline pumps. It was squarely bell-shaped, 10 inches in length, the bottom somewhat oval, and the largest portion of the nest (floor of the bell) measured 6 by 7 inches. When the place was visited on February 16 and again on February 27, the nest was completely covered with wasps; these, however, did nothing but rest quietly and only rarely did one or another leave the nest. An off-shoot of this colony was a nest built in an opening in the wall of the dwelling ten feet away. This was about one-fourth the size of the other and was, according to the proprietor, about six months old. This gentleman, Mr. J. Barrera, a keen observer of nature, said that the larger nest was two years old, and that the wasps on both nests had added nothing to their structures for some time, and only a few of them left the nest at long intervals, probably in quest of food. In fact, in answer to my subsequent letter inquiring about their resting period, he replied: "The wasps stopped their building activity about November 25, 1938, and started again on March 30, 1939. Our rainy season as a rule starts from May 25, to June 10, and ends about the end of November. The rest of the year, commonly termed the dry season, is not in reality dry, as we seldom have more than one week without rain. April and May are regarded as the driest months, nevertheless in April, 1939, we had 20.5 centimeters (8 inches) of rain."

This interesting observation on the resting period of this wasp is valuable in attempting to solve some of the problems of hibernation in wasps. Since we know that in the tropics swarming occurs among social wasps, we suspect that their activities go on continuously, with the surplus population going off from time to time, regardless of season, to found new colonies. Whether this suspicion is well founded is not known, since no record, so far as I know, has been made of hibernation or periods of rest for colonies of wasps in the tropics. But we do find, in the tropics of Mexico during the dry season, that a period of rest occurs; the wasps of this species, as we have seen, spend this interval quietly clinging to the inside or outside of the nest. In contrast to this in temperate regions, with the approach of autumn, the social wasps leave the domicile to seek hibernating quarters elsewhere. Now if in the deeper tropics it should be discovered that no resting stage

occurs, and that at any time when the colony becomes too large, portions fly away to found new nests, then we may see in the Mexican wasps a transition stage between actual hibernation away from the nest in the north, and a perennial growth of colonies with portions budding off from time to time in the tropics; the one group leaving the nest completely, the other not stopping activities at all, and the transition one, *P. occidentalis* for example, spending a period of inactivity without leaving the nest.

Of course, individuals at one time or another leave the home-domicile and found new colonies elsewhere. It is not known if *occidentalis* makes these swarming flights frequently during the year or if nest-founding is seasonal. In the tropical rain forest of Panama[2] I noted one instance where colony-founding occurred in September. In Mexico, I observed two such occurrences in February. These two colonies were found among the vine-covered ruins of a stone house near Iguala. One nest, the size of a small apple, was under the stone arch only a few inches away from a larger abandoned last year's nest of the same species. There were about 100 adults on the outside of it. The interior contained two combs of cells all of which were very shallow and incomplete, and contained neither eggs nor larvae. That the adult wasps had come in a swarm was indicated by the small size of the cells, none of which could possibly have harbored insects so large as were those on the nest. The second nest, a dozen feet away and 3 feet from the ground, was attached to a vine-stem in a deeply shaded, moist situation. This nest, with its occupying population, was scooped into a wide-mouthed cyanide jar, only about 50 of the wasps escaping in the melee. At the hour when this occurred, 11 a. m., on February 23, the outside of the nest was entirely covered with wasps. This nest is illustrated in fig. 7 (slightly reduced) with a portion of the wall removed to show the combs; fig. 8 is a portion of the roof-comb removed to show its attachment to the supporting twig. The nest measured three inches in height and the bottom comb was about three inches in diameter. The five combs contained about 2,500 cells, and, strange to say, not one of them was full-size, but all were merely cups, clean and empty; the cells of the top comb, however, were slightly deeper than the others, yet none were of adequate size to have produced any of the wasps that were on the nest.

[2]Jungle Bees and Wasps, p. 59, 1933.

A count of this population (preserved in alcohol) totaled 1,117. There was not a queen among them, nor any individual that stood out from the others by reason of size or coloration. The swarm was composed entirely of workers. All but 132 had protruded their stings in the struggle and these too were also identified as workers.

We may therefore conclude that this nest had had its start with a swarm of about 1,200 workers, who had busied themselves up to this date in making a nest of five combs containing 2,500 incomplete cells, and so far had deposited no eggs and had produced no young. Were they perhaps waiting for a queen to fly into the colony and commence egg-laying, or were they themselves the egg-layers, marking time until the eggs within their own bodies matured; and if so, will these eggs have been fertilized?

In writing about this species as observed in Panama (Jungle Bees and Wasps, 1933, pp. 56–65), I note that the species is distinguished for its mild-tempered behavior, its method of swarming in large numbers and the building of several combs early in nest-founding without depositing eggs in the cells as they are being constructed and the storing of a large amount of honey as well as of insects, often even before any young are in the nest to use it. The Mexican wasps of this species substantiate the first three of these items of conduct; they are mild mannered, they swarm and they build cells long before they are ready to produce the next generation. Insect prey has not been found, however, and I do not know if the Mexican wasps store honey, for the nest and colony were placed in alcohol before a study was made and the alcohol may have dissolved the honey if any was present. The small nest of a hundred workers mentioned earlier, however, contained no honey. The tantalizing point remains yet to be discovered; is there a queen, or do the workers, or part of them, lay the eggs? If there is a queen, at what period of nest-founding does she come upon the scene?

While examining some of the wasps with a lens, I discovered that their stings are barbed; with poor technique I counted six barbs on one sting but the number should be verified microscopically. In "Jungle Bees and Wasps," (pp. 82, 130), I record barbed stings for *Polybia simillima* and *Synocea surinama*, and it is not surprising, therefore, to find them in other members of the genus Polybia. The existence of barbed stings in social wasps seems to be not at all well known,

although I find that Latter (Bees and Wasps, p. 110, 1913) illustrates a barbed sting for *Vespa germanica*, and Duncan (Biology of North American Vespine Wasps, 1939) also figures a barbed sting in *Vespula pennsylvanica*.

Polistes carnifex Fab. [Bequaert.]

(Pl. I, figs. 13, 15½ nat. size, and 16)

Polistes carnifex (fig. 15) is a very large wasp, probably one of the largest in the genus. A round nest with three queens was taken under the eaves of a shed at Orizaba in February. The queens had evidently come out of hibernation and had started this co-operative venture, for the nest contained 25 thin shallow cells from which these adults could not possibly have hatched. Whether this was a joint undertaking with all queens sharing alike in work and egg-laying, is not known. The nest must have been commenced only recently as it was made of thin light-gray paper, and the cells contained only eggs. Fig. 16 shows a portion of this nest. It was very fragile and soon became broken and crushed in my knapsack. When I say the three adults had probably just emerged from hibernation, I base the statement on the fact that several other nests of this species were taken at Orizaba, Cordoba, Valles and Tamazunchale, but they were all last season's abandoned nests without occupants. *Carnifex* builds a substantial well rounded nest (fig. 13) with a pedicel ¼ to ½ inch in length placed in the center, and hangs in a horizontal position. The roof is unusually steep, sloping at an angle of about 30 degrees from horizontal. The cells of the nest are much deeper and wider than those of any other Polistes species; those in the center are often 1¾ inches deep; while those at the periphery are often 1 inch in depth. The new nests, as already stated, are made of flimsy, thin, light-colored paper, but the old ones are much darker in color, and heavier in texture; this is due in part to the spinning activities of pupating larvae, the accumulation of hardened larval excrement on the ceilings of the cells after a succession of young have occupied them and, most important of all, to the more liberal use of paper-pulp later in the season when there are many workers on hand to gather and to apply it to the structure. A comparison of figures 16 and 13 shows the difference in texture of a "queen-built" nest with that of a "worker-built" nest.[3] But even at best,

[3]In northern species of Polistes it was noticed that often queens use the building material very sparingly, spread it so thin that day-light can be seen through the nest.

the nests are papery and are not at all like the cardboard nests of Mischocyttarus described in later pages. Seven old nests that contained a sufficient number dead adults to be sure of the species, were taken at the localities already mentioned. All of them were built in man-made structures; all were in a horizontal position, and all had the characteristic steep roof. The nests varied in size from the smallest which was 1½ x 1½ inches in diameter, to the largest which measured 5¼ x 4¼ inches in diameter. Since these were all last season's nests, it is assumed that they had reached full size before they were abandoned; however, since pleometrosis occurs in this species the size of the nest may be regulated by the number of founding queens. (It is interesting to note that the largest nest—5¼ x 4¼ inches—had 228 cells from which adults had emerged, in some cases more than one from a cell, plus 35 peripheral unfinished ones.)

Judging from the giant size of the adults, one would expect the cells in which they had been reared to be larger than for smaller species of Polistes. Not only are they much deeper as I have already stated, they are also much wider; the diameter of three cells is slightly more than an inch, while in the nest of its contemporary, *Polistes major*, three cells measure only three-fourths inch. An examination of cell-size recalls the remarks of Tarlton Rayment (A Cluster of Bees, pp. 554–561, 1935) who finds apparent specific characters in the size of the cells of five species of bees belonging to the genus Apis. He says: "The cells of the giant-bee of India measure about four to the lineal inch; those of the hive-bee five to the inch; while the eastern honey-bee constructs six to the same measure. Then there is a hiatus, for the next are those of the Australian bee, and which measure nine to the inch, and last the small cells of the Indian flowerbee which builds ten to the lineal measure. I look forward, to discovering two new species, whose cells will measure seven and eight to the inch; the sequence will then be unbroken." Perhaps we may, likewise, with further study on many species of Polistes wasps, find similar phenomena which will throw some light on phylogenetic relationships of members of the genus.

Polistes canadensis var. **mexicanus** Bequaert [Bequaert]

A half-dozen specimens of this wasp were seen in the environs of Cuernavaca, Morelos, on February 22, 1939.

Polistes major Palisot de Beauvais [Bequaert].

(Pl. I, fig. 14, ½ nat. size)

Polistes major was taken on the wing on three occasions at Tamazunchale, and a newly begun nest with ten adults was taken at Orizaba, all in the last week of February. The perfectly round nest with pedicel in the center was under the eaves of a shed; it had 60 cells, 40 of which contained eggs and 20 contained small larvae. Here too, the cells were too small to have given forth adults and the ten wasps that were on it had come from elsewhere. A few abandoned nests from last season hung nearby, but this nest was the only one seen in course of construction. *P. major* (fig. 14) is a small edition of *P. carnifex*, and so alike are the two species in color and shape that I at first thought (even though they were on separate nests) that *P. major* was the worker caste of *P. carnifex*.

Mr. Richard Dow (Psyche, *39:* 14–15, 1932) records finding nests of *P. major* in Cuba, attached by a single pedicel to the underside of steel girders. One nest was oblong with 333 cells, the other was round with 214 cells. The wasps which he failed to capture when the nest was taken, returned later and rebuilt the same site.

Polistes instabilis De Sauss. [Bequaert].

(Pl. I, figs. 5, ¾ nat. size, and 6)

In the places we visited in Mexico, we found *P. instabilis* (fig. 5) in the beginning of the nesting season during the last of February. Here, as in some of the other species of Polistes mentioned in this paper, pleometrosis occurs, but occasionally also one finds a nest lorded over by a single queen.

This species was observed at Valles, Cordoba, Orizaba, and at Tamazunchale, all at low altitudes, and in all observations the nests were in early stages of construction. Near Valles, a 15-celled nest with one queen was found in a culvert under the highway; the cells were all shallow and ten contained small larvae, four had eggs, and one was empty. At Cordoba, among the vines overhanging the ruins of an old hacienda hung an elongated nest (fig. 6, ½ natural size) empty and of last year's making, but an inch above the nest, on the same stem, was a new nest of shallow cells with seven adults on it (fig. 6x). This swarm, like so many other colonies, had evidently come back to the old home after the resting season,and co-operatively built the new nest near the one they had long ago left. One wonders why they did not utilize the old nest, which was empty and in good condition. The new nest had

25 cells, with young larvae in the middle cells and eggs in the peripheral ones. In another part of the ruins, I noted nesting behavior which differed slightly from that mentioned above. Another last year's nest, somewhat pear-shaped, hung among the dense growth of vines over the ruined wall, but within a radius of 18 inches I found six small nests of *P. instabilis*, five of which were presided over by one queen, and one by two queens. The six nests comprised 18, 16, 14, 13, 12 and 12 cells and contained only eggs.

Six nests later observed at Orizaba hung in arches of ruins of what was apparently an old aqueduct. The condition of the six nests was as follows: one nest had 12 shallow cells and two presiding queens; one nest with two queens had 21 cells, 15 of which were very shallow and contained eggs and 6 somewhat deeper, with larvae about one-third grown; one nest had 11 shallow cells with eggs and one queen; one nest with four queens had 18 shallow cells, 15 of them with eggs and 3 with small larvae; the fifth nest had 13 shallow cells with eggs and only one queen, and the sixth nest, with three queens, had 25 shallow cells containing eggs only. Another nest of this species taken from a door-way at Tamazunchale had 14 shallow cells containing eggs, and one queen.

The pedicel is always at the top of the pear-shaped nest and it hangs vertically. The nests get quite large by the end of the season; several abandoned nests of last season containing dead wasps were taken, the largest of which measured 12 inches in length and 3¾ inches at its widest point near the bottom.

In Polistes nests where the pedicel is placed in the center, as in the species *pallipes*, *variatus*, *major* and *carnifex*, the comb assumes a horizontal position, while in cases where it is placed off-center, as in *annularis*, the nest assumes a diagonal position among the vegetation. But several species of *Polistes*, as *P. canadensis* var. *panamensis* build nests as do *P. instabilis*, with the pedicel at the top of the comb and the nest hangs in a vertical position.

MISCHOCYTTARUS WASPS

Four species of social wasps belonging to the genus Mischocyttarus were observed in Mexico. All four species make single comb nests which are usually round but sometimes roughly oblong and always without a paper covering. They hang horizontally from man-made structures, and as is usual with

social wasps, the openings of the cells are on the under side of the nest. The domicile is constructed of a substantial brown cardboard-like material (figs. 1 to 4, 11, 12), considerably heavier than the papery material used by Polistes wasps in the same region. The nests have short pedicels, usually at or near the center. Some sister species, however, do not have short pedicels, as may be seen in the species *labiatus* (fig. 62 in Jungle Bees and Wasps, 1933) where the pedicel which carries a nest of polistes-like cells is very thin and very long. Nor is the short pedicel of some species placed in the center of the roof, as may be seen for *M. flavitaris* var. *navajo* in fig. 1 of Bequaert's paper on "Social Wasps of the sub-family *Polybiinae*."[4] Another species (fig. 64 in Jungle Bees and Wasps) makes a whip-like nest, of single or double rows of cells, sometimes 18 inches long, with a pedicel at the top; while the species *M. longipetiolatus* (fig. 63 in Jungle Bees and Wasps) has the pedicel at one end of the roof of nests that hang horizontally. The nests of Michocyttarus in Mexico do not attain great size. An examination of twenty of last season's nests of unknown species, belonging to this genus (fig. 12 is a sample) measured for the round ones, from 1 inch by 1 inch to 2¼ inches by 2 inches; for those that were roughly oblong the size varied from the smallest, 1 x 2 inches, to the largest, 3½ x 1¾ inches. One nest, however, the largest taken, was somewhat triangular in shape (fig. 11), measured 3½ x 3½ inches in diameter at its widest points and contained about 290 full sized cells. Since wasps seldom or never abandon their nests in mid-season, it is assumed that the above mentioned nests had attained full size when the season ended.

During February all four species discussed in these pages, were in the early stages of nest-founding. Since many old nests were seen in the various localities, and since all of them were without colonies of living wasps, it is evident that the adults on the newly made nests have had only recently come out of hibernation and that the month of February is the probable beginning of the nesting season.

The larvae of all species observed spin silken covers over their cells, and unlike Polistes larvae which spin covers of white silk quite in contrast with the gray color of the nest, Mischocyttarus spins a brown silk which identically matches the nest. It would be interesting to know whether the liquid

[4]Entomologica Americana 13 N. S. 87–150, 1933.

silk is naturally brown, or if perhaps some of the nest wall is masticated and mixed with it as it leaves the spinning glands.

Mischocyttarus ater Oliver. [Jos. Bequaert].

A tiny nest of three shallow cells, one of which contained an egg, was discovered among the mass of disintegrating moss under an arch at Cordoba on February 20. The color of the nest was the same as the surrounding material and would not have been discovered had not the queen been seen to alight on it.

Mischocyttarus basimacula Cameron[5] [Richards].

A nest of this species was taken from a culvert under the Pan-American Highway about 45 kilometers north of Tamazunchale. The nest was round, made of brown cardboard-like material, contained 42 cells and had 3 founding-queens on it. The cells were of various sizes, but none were sufficiently large to have given forth the adults that were on the nest. Nine of the cells were sealed and the others contained eggs and larvae of various sizes, and none of the cells contained honey. *M. basimacula* was also taken by me in Panama and nests are illustrated in fig. 63 of Jungle Bees and Wasps. The nests from both localities are very much alike.

Mischocyttarus cubensis var **mexicanus,** de Saussure [Richards].

Observations were made on three colonies of this species; two of them were taken from a culvert under the highway near Canyon de Galeana, about 50 Kilometers north of Limon. One nest, with 40 cells containing eggs, larvae, and pupa, had 6 founding queens. The second nest with only one queen and 13 cells, four of which had small larvae, nine cells with eggs. In each cell with an egg, there was a droplet of honey. While all nests of this genus observed in Mexico hung horizontally, this one was attached to the back of a vertically hanging abandoned nest of *Polistes instabilis*, and even though its pedicel was in the center, the nest naturally assumed a vertical position. The third nest of this species, taken in a culvert near Victoria, had 12 cells with eggs or larvae and one founding-queen. In all of the three colonies, the adults had come from elsewhere, and had not hatched from the nests on which they were found, for in all cases the nests

[5]This, and the following two species were kindly sent by Dr. Bequaert to Dr. Richards of London, England, for identification. Dr. Richards will soon publish a description of the new species, *M. immarginatus* discussed below. I am deeply grateful to both gentlemen for these identifications.

were in the early stages of construction, and the cells were too small to have harbored these adults.

Figures of the nest and interesting data on *M. cubensis* are given by Bequaert in the already cited paper, but no mention is made of variety *mexicanus*.

Mischocyttarus immarginatus Richards. [Richards]. New Species.[6]

(Pl. I, figs. 1–4, 9 and 10)

Fifteen colonies of this new species were taken at Canyon de Galeana (50 kilometers north of Limon), Valles, Victoria, Tamazunchale and Cordoba. A detailed study of these colonies are tabulated below. The nests of all were in the early stage of founding, and nesting progress ranged all the way from a group of queens congregating preparatory to nest building (No. 3 in table) to colonies so far advanced as to have already given birth to a few adult young (nests 6, 8 and 9). Most of the nests at the time of collecting, however, contained eggs or larvae. A 6 cell and an 18 cell nest are illustrated in figures 9 and 10 respectively. The 15 nests had a total of 322 cells, 299 of which had eggs or larvae and 23 had pupae.

Besides the few individuals of the new generation that emerged from the nests (Nos. 6, 8, 9 in table) all of the nests gave evidence of the adults having come from elsewhere. They had evidently come to the old homesite from the hibernating quarters and built new nests near them. This may be seen in two cases where they actually attached the new nests on the old ones (see "arrow" in fig. 1 and "x" in fig. 2). While pleometrosis occurs abundantly in this species, I also observed nests with only one founding-queen; the table shows that of the 15 nests, six were presided over by one queen, and nine have been founded by from two to ten queens. In nest 9, there were three small individuals on the nest; these may have been newly born normal size workers or they may have been stunted workers. We sometimes find in social wasps, because of poor nourishment, the first offspring are dwarfed individuals. It was so noted for *Polistes variatus* and *P. annularis*, as well as for *Vespa maculata* (see Ecology, 20: 440, 1939).

Like many of their relatives, these wasps gather and store honey; in the table, one may note that honey was found in five nests (Nos. 6, 9, 10 and 11); in some nests the droplets

[6] A description of this new species by Dr. O. W. Richards is to appear in the February number of Ann. Mag. Nat. History, 1940.

TABLE I

Nest No.	Location	No. of Adults on Nest	No. of Cells in Nest	Cells with Eggs	Cells with Larvae	Cells with Pupae	Remarks
1	Canyon de Galeana.....	1	8	7	1	.....	Nest in culvert.
2	Canyon de Galeana.....	2	6	6	.....	.....	Nest in culvert. (See fig. 9.)
3	Valles.....	10	.....	.....	.....	.....	All adults on old nest in culvert; no new cells in evidence. Congregating in preparation of nest-founding.
4	Valles.....	1	9	9	.....	.....	Nest in culvert.
5	Valles.....	1	13	9	2	2	Nest attached to old one; in fig. 1; nest in culvert.
6	Victoria.....	7	65	40	17	8	Much honey—some empty cells large enough to have given forth adults; 4 of the adults emerged at St. Louis March 19 to April 11, 1939. (See fig. 4.)
7	Tamazunchale	5	28	15	12	1	Nest on ceiling of shed—several cells had honey.
8	Tamazunchale	6	62	30	28	4	Nest figured as No. 3. Under eaves of shed; 3 cells had been used second time, only half of the adults therefore are founding queens.
9	Tamazunchale	8	65	25	30	4	Nest in doorway; cells had honey. Three cells had given forth adults and there were 3 undersized adults on nest.
10	Tamazunchale	2	11	6	4	1	Nest under window sill in cottage; one cell had an enormous amount of honey.
11	Tamazunchale	2	11	7	2	2	Nest under eaves; one cell had a good amount of honey.
12	Tamazunchale	1	18	17	1	.....	Nest over doorway of cottage. (See fig. 10.)
13	Tamazunchale	1	9	5	3	1	Nest under roof of shed.
14	Tamazunchale	1	8	8	.....	.....	Nest under roof of shed.
15	Cordoba.....	2	9	9	.....	.....	Nest in building. New nest attached to an abandoned one. (See fig. 2.)
	Total.....	50	322	193	106	23	

were placed in cells with eggs, in others, it was stored in empty cells; in most cases they were small drops, in others however, they were large masses.[7]

The shape of the nests of this species during the early stages are almost always round as may be seen in figs. 3, 4, 9 and 10 and also at "arrow" in fig. 1 and at "x" in fig. 2. The completed nest is probably irregular in shape as may be seen in the old nests (which may or may not belong to this species) upon which the new ones are attached (figs. 1, 2).

[7]An important summary of the honey gathering habits of wasps is given by Dr. Bequaert in the already cited paper.

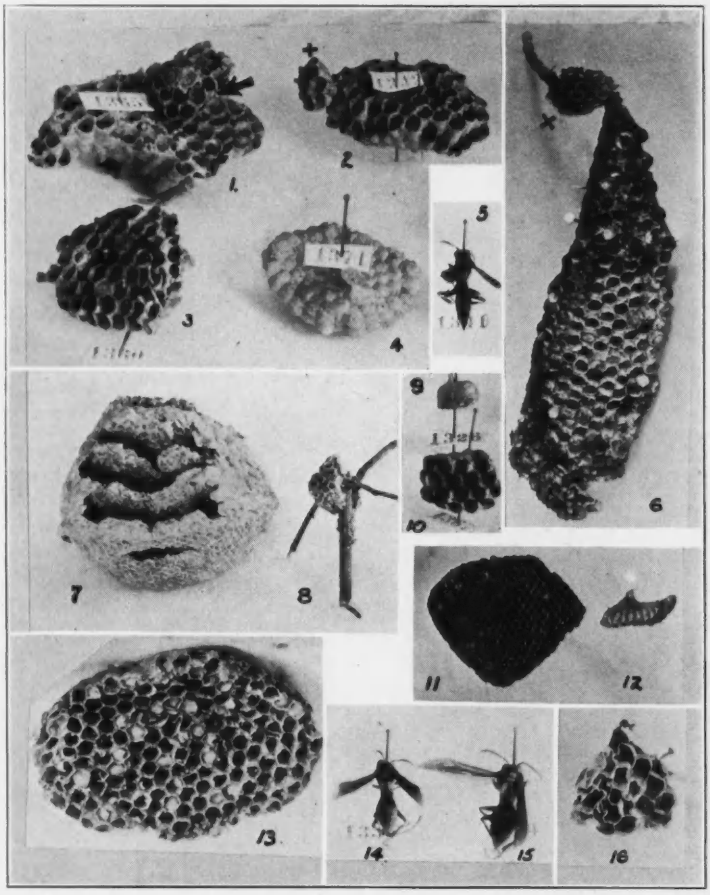

Fig. 1, A last season's nest of *Mischocyttarus* sp., with newly-founded (see arrow) nest of *M. immarginatus* attached. (Slightly reduced.) Fig. 1 is described in Table as Nest 5. 2, Another nest of the same species with newly-founded nest of *M. immarginatus* attached at "+." (Slightly reduced.) Fig. 2 is described in table as Nest 15. 3 and 4, Two nests of *Mischocyttarus immarginatus*. Figures 3 and 4 are described in table as nests Nos. 6 and 7 respectively. (Slightly reduced.) 5, Queen of *Polistes instabilis*. 6, A last season's nest of *Polistes instabilis* with a newly begun this season's nest at "x." (½ natural size.) 7, Nest of *Polybia occidentalis*, (½ natural size) with a portion of the wall removed to show the combs. The lowest and largest comb measured at its widest points 3½ x 3¼ inches in diameter. 8, A portion of the top-most comb at its point of attachment to the support (*P. occidentalis*). 9 and 10, Newly begun nests of *Mischocyttarus immarginatus*. Nos. 9 and 10 are described in Table as Nos. 2 and 12. 11 and 12, Nests of *Mischocyttarus* sp. 13, A full size nest of *Polistes carnifex* (half natural size). 14, Queen of *Polistes major*. 15, Queen of *Polistes carnifex*. 16, A nest of *Polistes carnifex* in the early stages of construction.

MONOBIA, MONTEZUMIA AND PACHYMENES, NEOTROPICAL ELEMENTS IN THE NEARCTIC FAUNA

(Hymenoptera, Vespidae)

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The diplopterous wasp fauna of the Nearctic Region consists of three biogeographical elements.[1] (1) A few groups are apparently precinctive, showing no close affinities to wasps of other regions, at least in the living fauna: *Euparagia*, *Pseudomasaris*, *Maricopodynerus*, and *Dolichodynerus*. These form a very small percentage of the fauna (probably not more than 5%) and are almost restricted to the western United States. (2) The bulk of the species (probably over 80%) belong to Holarctic groups: *Vespula*, *Eumenes*, *Odynerus* s. str. (or *Hoplomerus*), *Ancistrocerus*, *Symmorphus*, *Leptochilus*, *Rygchium* and *Pterochilus*. In most cases the relationships to Palearctic species are unmistakable, the Nearctic forms differing sometimes in color only. (3) Finally some typical Neotropical groups have invaded the Nearctic Region, perhaps since the retreat of the Glaciers: *Monobia*, *Montezumia*, *Pachymenes*, *Pachodynerus*, *Zethusculus*, *Pseudodynerus*, *Mischocyttarus* and *Nectarina*. The few Nearctic species of *Polistes* are also related to Neotropical forms, not to Palearctic species. In all the Neotropical element probably represents between 5 and 10% of the fauna. The distribution of *Mischocyttarus* and *Nectarina* was discussed in 1933 (Entomologica Americana, 13, pp. 87–150). That of *Polistes* and *Pseudodynerus* is considered in forthcoming papers. The present article deals with *Monobia*, *Montezumia* and *Pachymenes*.

Monobia de Saussure

A synopsis of this genus will be published elsewhere. It appears to be a strictly American group, almost restricted to Central and South America. Of the 22 structural species which I recognize at present, two only enter the boundaries of the United States.

[1]Species which are unquestionably recent introductions by man are not considered in this discussion.

Monobia quadridens (Linnaeus)

Vespa quadridens Linnaeus, 1763; *Vespa quadricornis* Degeer, 1773; *Vespa cincta* Degeer, 1773; *Vespa uncinata* Fabricius, 1775; and *Vespa incincta* Fabricius, 1804, are synonyms.

A common wasp in the eastern United States, where it is known from southeastern New Hampshire (Hampton, Rockingham Co.), eastern Massachusetts (Cape Cod; Boston; Reading), Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, West Virginia, District of Columbia, Georgia, Virginia, North Carolina, South Carolina, Florida, Alabama, Kentucky, Mississippi, Louisiana, Arkansas, Tennessee, Texas, Oklahoma, Kansas, New Mexico (Jemez Springs, westernmost locality), Missouri, Indiana, Illinois, and Ohio.

Monobia texana (Cresson)

Odynerus texanus Cresson, 1872, *Monobia californica* de Saussure, 1875, and *Monobia variabilis* de Saussure, 1875, appear to have been all based upon the same species, as will be shown elsewhere.

Cresson originally described it from Bosque Co., Texas. I have seen the type at the U. S. Nat. Mus.; also specimens from Arizona: Palmerlee, one female; Sabino Canyon, Sa. Catalina Mts., one female and one male; as well as from the State of Sonora, Mexico: Estrella District, Alamos, two females; Posa, one male; Cajene, one male. *M. californica* was described from Cape St. Lucas, Lower California, and *M. variabilis* from Cordova, State of Vera Cruz.

M. texana differs from *M. quadridens* not only in color (being extensively ferruginous), but also structurally (shape of clypeus, propodeum, first tergite, second sternite and male terminalia).

Montezumia de Saussure

Some years ago I published a synopsis of this genus (1921, Rev. Zoolog. Afric., 9, pp. 235–251). I have since reached the conclusion that the generic name should be restricted to the American wasps, which I then placed in *Montezumia*, proper, some 30 species in all. Nearly all of these are Neotropical, but one apparently undescribed species occurs in Arizona.

Montezumia arizonensis, new species

A large, stubby species. Ferruginous and black, extensively marked with yellow on the abdomen. Wings violaceous-black. Propodeum with

the lateral angles completely rounded off. Second and third tergites with a broad, translucent apical lamella.

Length (h.+th.+t.1+2): ♀, 18 to 19 mm.; of fore wing, 19 to 20 mm.

Female.—Head (fig. 1C) subcircular seen in front, nearly as high as wide; seen from above, transverse, about twice as wide as long; occipital margin almost straight. Vertex and cheeks margined throughout by a sharp carina, raised and lamellate on the cheeks, somewhat lower on the occiput. Cheeks very wide and much swollen in their upper half, where they are much wider than the upper part of the eye in profile, gradually narrowed below; marginal carina evenly curved, convex, and running far from the eye, even at the mandible. Inner orbits scarcely farther apart on the vertex than at the clypeus; upper half of frons not appreciably swollen. Ocelli in a flattened triangle; posterior pair about as far apart as from the eyes and about twice as far from the occipital margin. Interocellar area flat. Vertex with a semi-elliptical fovea, the posterior margin of which is more raised, with two densely hairy pits. Antennal sockets about twice as far apart as from the eyes; area between them much raised and with a strong, blunt, median, even keel. Clypeus broadly pear-shaped, about as long as its greatest width, moderately convex, very slightly flattened anteriorly; apical, free portion much longer than basal, interocular part; apical margin about one-fifth of the greatest width of the clypeus, with a slight and uniformly curved emargination, the lateral angles blunt, not carinate. Antenna: flagellum scarcely swollen apically. Mandible slightly shorter than the height of the eye, straight, rather broad; apex very bluntly rounded; inner cutting edge divided into four long, low teeth. Maxillary palpi of five segments: first thicker and slightly longer than second; third to fifth much shorter, slender and very slightly decreasing in length. Labial palpi of three heavy segments; first the longest; third less than half as long as second; tips of second and third bearing a few heavy, curved setae; no trace of a fourth segment. Thorax (fig. 1A) rectangular, slightly narrower anteriorly than posteriorly, nearly one and a half times as long as wide and not quite as high in profile as wide across the tegulae. Pronotum slightly and evenly narrowed toward the humeral margin, which has a very slight inward curve and bears a continuous, sharp carina of about the same height throughout; humeral angles scarcely indicated, rounded off; sides of pronotum evenly rounded off between dorsal and lateral areas. Mesonotum slightly longer than wide; notauli deep and groove-like in posterior third, gradually fading to near pronotum. Tegula over twice as long as wide in the middle; hind margin evenly rounded into outer margin. Post-tegula small, slightly curved. Scutellum rectangular, nearly twice as wide as long, nearly flat, with a faint, longitudinal, median impressed line. Postscutellum very broadly triangular, much shorter than scutellum, from which it is separated by a deep, smooth suture, obliquely sloping throughout, somewhat swollen and divided by a slight longitudinal depression over anterior third, not crenulate. Mesepisternal suture complete; a strong, bluntly carinate prepectal suture, from the mesepisternal suture to near the base of the mid-coxa. Propodeum short, squarely and vertically truncate behind,

scarcely swollen on the sides; dorsal areas barely touching each other behind postscutellum (seen from above); concavity wide and very shallow, evenly rounded off into the dorsal areas; superior ridges not marked; lateral ridges weak, blunt; inferior ridges broadly rounded off; lateral angles not at all prominent, very broadly rounded off; no teeth near the articular valvulae. Abdomen (fig. 1A and B) broad and stubby, gradually narrowed toward the first segment, somewhat depressed. First tergite rather short, transverse, about one and a half times as wide as long, distinctly narrower than second tergite, seen from above; in outline dome-shaped, the spiracles not projecting laterally; in profile about half

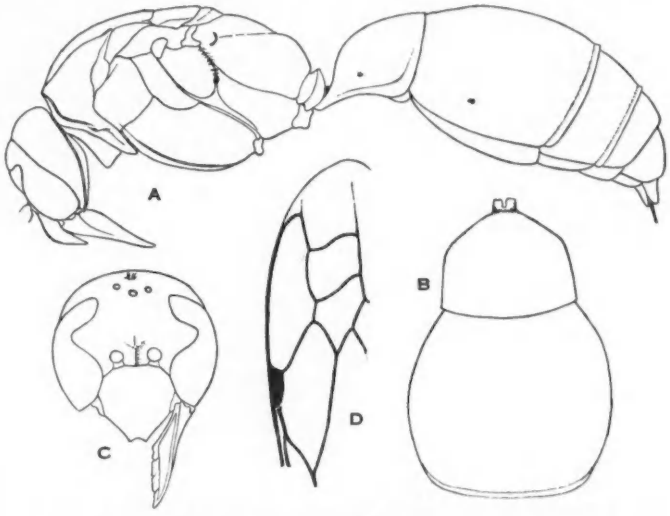

Fig. 1. *Montezumia arizonensis* J. Bequaert, female: A, body in profile; B, abdomen from above; C, head in front view; D, apex of fore wing.

the length of second tergite, evenly and convexly sloping from apical margin to basal articulation, with a slight longitudinal, median groove; apical margin not thickened nor raised, narrowly translucent at the edge. Second tergite about as long as wide, slightly convex, seen from above distinctly widened in hind half. Apical margin of second and third tergites duplicate, bearing a broad, conspicuous, even, translucent, slightly raised lamella, which is separated from the remainder of the dorsum by a fine, minutely foveolate depressed line. Second and third sternites also lamellar at apex, but flat. Second sternite almost flat throughout, basally without longitudinal furrow, but with a slight, strongly ribbed transverse groove. Legs stout; coxae normal. Venation (fig. 1D) as usual.

Head and thorax very densely and uniformly covered with coarse punctures, the narrow intervals between these with much finer punctures. Clypeus much less coarsely punctate than frons; anterior face of pronotum smooth; metapleura nearly smooth, with a few heavy ribs in the upper sutures; tegulae mostly with minute punctures; concavity of propodeum punctate like the dorsal areas and in addition with some transverse striae. Abdomen with scattered, fine, fairly uniformly distributed punctures, both dorsally and ventrally; those of the first tergite somewhat larger. Pilosity very short and somewhat velvety, particularly on the abdomen.

Head, thorax and legs mostly ferruginous-red, with the following black areas: middle of frons to above the ocelli; an arcuate streak above the depression of vertex, extending over the occipital margin; most of flagellum above; teeth and tip of mandible; most of sutures of thorax; a median streak on mesonotum, widened anteriorly and posteriorly; anterior and posterior margins and median line of scutellum; extensive blotches on pleura and sternum; most of concavity of propodeum. Some of the ferruginous has an orange tinge. First and second abdominal segments black variegated with ferruginous-red. Apices of all tergites and of all sternites except first very broadly margined with pale sulphur-yellow, that color covering most of the third to sixth segments. Sometimes the middle of the pronotum has a faint trace of yellow. Wings black throughout, with violaceous reflections; stigma and veins black.

ARIZONA: Sabino Canyon, Sa. Catalina Mountains, Pima Co., female holotype, July 23, 1917 (J. Bequaert); Palmerlee (or Garces), Cochise Co., female paratype (C. R. Biederman); Huachuca Mountains, Cochise Co., female paratype (M. Cazier). All Museum of Comparative Zoölogy, Cambridge, Mass.

M. arizonensis is on the border line of *Monobia* and *Montezumia*, the limits between these genera being arbitrary. The first tergite is, however, distinctly narrower than in *Monobia texana*, which it resembles superficially. Probably the first tergite of the male will be even narrower than that of the female. It is readily separated from *texana* by the short, rounded propodeum and the peculiar apical lamellae of second and third tergites. These characters also distinguish it from the Mexican *Montezumia azteca* de Saussure (which is uniformly bluish-black), *M. huasteca* de Saussure (which is black, with a few yellow markings) and *M. mexicana* de Saussure (which is mostly ferruginous-red, with very few or no yellow markings). *M. mexicana*, which I have seen from Mexico (Tierra Colorado, Guerrero; Tepic, Est. Tepic; Cuernavaca, Morelos), has a much narrower first tergite and the postscutellum with a transverse, crenulate ridge, not present in *M. arizonensis*.

Pachymenes de Saussure

The North American wasps here placed in *Pachymenes*, were included in *Nortonia* by de Saussure, Zavattari and others. They are, however, not related to the genotype of *Nortonia*, *Odynerus intermedius* de Saussure. Though best retained in *Pachymenes*, they differ quite decidedly from the genotype, *Pachymenes sericeus* de Saussure, in the shape of the first abdominal segment. In *P. symmorphus*, *P. toltecus* and related forms, the first tergite is broadly and regularly funnel-shaped, though at the same time only half as wide as the second; the basal stalk is very short and the outline of the tergite seen from above is pentagonal; the apical margin is not raised or thickened, but flat and lamellar. These wasps have the appearance of certain *Montezumia*, from which they differ only in the 6-segmented maxillary palpi and the distinctly 4-segmented labial palpi. A. de Winkelried Bertoni proposed for them the subgeneric name *Paranortonia* (1934, Rev. Soc. Cientif. Paraguay, 3, p. 109), specifically for *Nortonia tolteca* de Saussure, 1875, *Nortonia sulcata* Ducke, 1904, and *Nortonia surinama* A. v. Schulthess, 1903. I designate herewith *Nortonia tolteca* as the subgenotype of *Paranortonia*, in which I include also *Odynerus symmorphus* de Saussure, 1855, and *Odynerus* (?) *carinulatus* Spinola, 1851. I have taken an apparently undescribed species in Yucatan.

Pachymenes (Paranortonia) symmorphus (de Saussure)

The typical color form was described as *Odynerus symmorphus* de Saussure, 1855, from Florida. This is a black wasp, sparsely marked with yellow on the head, antennae, pronotum, legs and apices of first and second tergites, the yellow areas sometimes edged with russet and the tegulae ferruginous; the wings violaceous-black. One female from Texas has some russet on the pronotum, scutellum and apex of second tergite; but the yellow markings are as usual. This wasp is widely distributed throughout the eastern United States, but always rare. I have seen it from Vermont (Stowe, Lamoille Co.), New Hampshire (Lyne, at flowers of *Pastinaca sativa*), Massachusetts (Salem; Reading; Forest Hills; Newton, Minot Co.; Holliston), Rhode Island (Tiverton), New York (Oswego; Minetto, Oswego Co.; Greene Co.; Ithaca; Greenwood Lake; White Plains, at flowers of *Ceanothus americanus;* West Nyack; Patterson), New Jersey (West Englewood; Bergenfield; Ramsey), Pennsylvania (Pittsburgh; Ligonier, Westmoreland Co.), Maryland (Cabin John

Run), Virginia (Falls Church; Roslyn; Great Falls; Glencarlyn), North Carolina (Raleigh; Warsaw), Georgia (Okefenokee Swamp), Illinois (Algonquin), Iowa (Davenport; Clayton Co.), Texas (Fedor, Lee Co.), Oklahoma (Page), and eastern Kansas (Baldwin). It is also recorded from Connecticut.

P. symmorphus var. (or subsp.) **sonorensis,** new

Female.—Black, more or less ferruginous on antennae, clypeus, mandibles, pronotum, tegulae, propodeum, legs and first and second abdominal segments; mesonotum black. Yellow markings very extensive on clypeus, between antennae, on inner and outer orbits, pronotum, tegulae, scutellum, postscutellum, pleura, propodeum, legs and apical margins of all tergites and most sternites; these apical margins are usually very broad, covering most of the third to sixth tergites. The female paratype from Platte Canyon even bears two large yellow discal free spots near the middle line of the second tergite. Wings ferruginous-infuscate or amber-yellow, often clearer than in typical *symmorphus* and only slightly violaceous.

Male.—Similar to the female, but the clypeus entirely yellow.

COLORADO: Plainview, Jefferson Co., female holotype, male allotype and male paratype (Geo. P. Engelhardt); Turkey Creek Canyon, male paratype (Oslar); Platte Canyon, female paratype (Oslar); Lake Isabelle, Ward, male paratype; Jim Creek near Boulder, male paratype; Ft. Collins, male paratype. ARIZONA: four male and female paratypes, without more definite locality; Baboquivari Mts., Pima Co., male paratype (O. C. Poling); Santa Rita Mts., Pima Co., two male paratypes; Huachuca Mts., Carr Co., male paratype (E. P. Van Duzee). Holotype, allotype and paratypes at Mus. Comp. Zoöl., Cambridge, Mass.; paratypes also at California Ac. Sci., U. S. Nat. Mus., Academy of Nat. Sci. Philadelphia, Amer. Mus. Nat. Hist., and in R. M. Bohart collection.

This color form is structurally and in sculpture exactly like typical *P. symmorphus*, with which it intergrades in Texas. It is an insect of the Upper Sonoran life zone in the United States and no doubt will be found also in northern Mexico. It has been called thus far *P. toltecus* in collections. Some of the variants which de Saussure noted under *toltecus*, may have been var. *sonorensis*.

P. symmorphus var. **toltecus** (de Saussure)

Nortonia tolteca de Saussure (1875) was originally described from several localities in Mexico: Valley of Metztitlan, State of Hidalgo; Moralia, State of Michoacan; Patzcuaro, State of

Michoacan; and Cordova, State of Vera Cruz. Some of these specimens appear to have been of the var. *sonorensis;* but the name *toltecus* is here restricted to the main form figured by de Saussure on Plate, 2 fig. 13. Unfortunately, the locality of this specimen is not definitely given. This main form is almost entirely ferruginous with a few black blotches, mainly at the sutures; the mesonotum is usually mostly ferruginous, rarely black with two curved ferruginous lines; the yellow markings are few, sometimes almost lacking; the wings are darker than in the var. *sonorensis* and strongly violaceous. A most careful comparison shows no reliable difference in structure or sculpture from typical *P. symmorphus* of the eastern United States. I have seen the var. *toltecus* from Mexico: Guadalajara, State of Jalisco, one female and two males (McClendon and Crawford); Estrella District, Alamos, State of Sonora, one female; Guaymas, State of Sonora, one female (W. M. Mann). Also from Arizona: Sa. Rita Mts.; Sabine Canyon, Sa. Catalina Mts.; and from Texas (without more definite locality).

GEBRÄUCHLICHE NAMEN VON SCHADINSEKTEN IN VERSCHIEDENEN LÄNDERN by Dr. Gunther Schmidt. (First Part and the first forty pages of Second Part.) Pages 1–160, vol. 6 (March 25, 1939) of the Entomologische Beihefte aus Berlin-Dahlem. Edited by Dr. Hans Sachtleben (and Dr. Walther Horn). Published by the Deutsches Entomologisches Institut der Kaiser Wilhelm-Gesellschaft, Berlin-Dahlem, Gossler Str. 20. Price (paper bound) RM8.

This work by Dr. Günther Schmidt of the Deutsches Entomologisches Institut is just what its title indicates. It is a series of lists of common names of insect pests. It is very conveniently designed in that it also reverses the lists and gives lists of the scientific names following each of which is the common name and sometimes in more than one language. The common names are given in German, English, French, Italian, Spanish, Dutch and the speech of the Boers of the South African Union.

A forerunner of the present list which was written by Dr. H. Morstatt was published by the Deutsches Entomologisches Institut as No. 10 of "Supplementa Entomologica" in 1924. It listed about 2000 names but omitted German names. Since then has appeared the American list, "Common Names of Insects Approved for General Use by the American Association of Economic Entomologists." Jour. Ec. Ent. 30: 527–560, 1937. This listed about 1000 names. All such lists of various kinds have been brought together and a list of German names added in the present work which it is planned to complete in vol. VII (1940) of the Entomologische Beihefte. We hope the present unrest in Europe does not hold this important work up.

We have not seen the second part of the work. The part at hand has, following a short introduction, a list of German common names of pests (pp. 8–62), a list of the species by scientific names (pp. 63–102) and a list of genera (pp. 103–119). On page 120 begins Part II which with an introduction of three and a half pages is the list of "Common Foreign Names" (foreign to Germany). The part in hand closes on page one hundred sixty with "European furniture beetle Anobium punctatum De G.; Anobiid. (Col.)."—C. H. K.

THE INTRODUCTION OF AN INDIGENOUS BLOWFLY PARASITE, ALYSIA RIDIBUNDA SAY, INTO UVALDE COUNTY, TEXAS

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The great injury by blowflies to the livestock industry in Texas and the occurrence of a braconid, *Alysia ridibunda* Say, in abundance as a parasite of blowfly larvae in New Mexico and Arizona led to attempts to introduce this species into southwestern Texas, where several years' work comprising thousands of observations and tests during all seasons of the year indicated that this parasite was not present.

The transfer of a beneficial native insect parasite from one section of a continent to another section where it does not occur is usually considered to be impracticable unless definite physical barriers such as deserts, mountains, or water have prevented its natural spread to that section. There is a possibility, however, that other barriers, not so readily perceptible, such as wind movement and other climatic conditions, may serve to prevent species from spreading to areas similar in climate and flora. Furthermore, as it is well known that indigenous noxious insects have been accidentally introduced into new areas within North America and have become established as destructive pests, it is reasonable to infer that beneficial parasites of these pests might also be transferred and become established.

Alysia ridibunda is one of several blowfly parasites discovered in a general survey of the Southwestern States from Mississippi to California, and in cursory local surveys in Florida, South Carolina, Maryland, Virginia, Illinois, and Oregon. In the survey 4,740 exposures of meat baits were made over approximately 10,000 miles of circuitous routes by the Uvalde, Tex., laboratory of the Bureau of Entomology and Plant Quarantine during the years 1931 to 1934. The surveys indicated distribution of the species to be in the river valleys in southern Arizona and New Mexico, although adult specimens have been taken

[1]Acknowledgment is made to D. C. Parman, who initiated the idea of the survey and introduction of the blowfly parasites, and under whose general direction this work was carried out.

generally over the eastern part of the United States and in parts of Canada.

The first record of *Alysia ridibunda* as a parasite of blowfly larvae was published by the writer (1932) as a result of a survey in New Mexico and Arizona. Specimens of the parasite were reared from blowfly larvae collected at Las Cruces, Deming, and Socorro, N. Mex., and Duncan, Ariz. At a later date D. C. Parman collected specimens at Bisbee, Douglas, Globe, Tucson, and Florence, Ariz.

The following account deals with the rearing, release, and establishment of this parasite in Uvalde County, Tex. Although it was not found to be present in numbers each succeeding year after its introduction, it is believed that the information secured may be of value to other workers in efforts along similar lines.

CLIMATOLOGICAL COMPARISONS

In many ways the climate, fauna, and flora of the above-mentioned localities are similar to those of southwestern Texas. Both areas are classified as semiarid and produce typical semiarid flora and fauna. The annual mean temperatures compare favorably. The annual temperatures in localities from which *Alysia ridibunda* was collected ranged from 58.2° F. at San Marcial, N. Mex., to 68.8° at Florence, Ariz., while at Uvalde the average is 69.7°. The annual rainfall is not so comparable, since the precipitation ranges from 8.5 inches at Las Cruces, N. Mex., to 18.5 at Bisbee, Ariz., while the average at Uvalde is 23.7 inches although decreasing westward to 19.06 inches at Del Rio and is as low as 10 inches in the Pecos Valley in Texas. In general the similarity of the two sections suggested that *A. ridibunda* might be successfully introduced into southwestern Texas.

REARING METHODS

Work was begun in September, 1933, to breed *Alysia ridibunda* in the laboratory in large numbers for release. Approximately 120 specimens were at hand, and a season was consumed in devising satisfactory methods of mass rearing and building up a surplus population of the parasite. Early in the work it became apparent that the parasite would not go through its life cycle on *Cochliomyia macellaria* (F.), the common blowfly of the Southwest, but would readily mature in *Sarcophaga* and *Lucilia* larvae. Since *Lucilia* flies were more easily handled in the laboratory than those of Sarcophaga, most of the parasites were reared on larvae of *L. sericata* (Meig.) and *L. mexicana* Macq.

The rearing method that proved the most satisfactory is briefly as follows: A stock of gravid flies was kept on hand for egg production.

Maggot-infested beef and rabbit were exposed on sand in small pans to the parasites in cages. The greatest difficulty encountered was the control of large masses of mature maggots, because *Lucilia* larvae have strong migratory tendencies. The method which proved most effective in handling the larvae was to place the infested meat on 2 inches of dry sand in a galvanized-iron tub. This was placed inside another tub and that within another, each containing 2 inches of dry sand. If the sand was kept dry, most of the migrating larvae were prevented from escaping. The larvae were then stored in 10-gallon lard cans the tops of which were covered with 60-mesh screen wire to permit ventilation and to keep out hyperparasites and predators. After pupation the material was stored in emergence boxes.

DURATION OF IMMATURE STAGES

In the course of breeding work it became evident that the developmental period of the parasite varied considerably, depending to a certain extent on whether parasitization took place in the fall, spring, or summer. Both in the laboratory and in the field the parasite exhibited a dormant or aestivation period in midsummer. Roberts (1935) showed the development of the summer broods to require from 20 to 45 days and that of the overwintering individuals from 121 to 174 days.

TABLE I

COMPARISON OF EMERGENCE OF *Alysia ridibunda* FROM MATERIAL PARASITIZED OCTOBER 1 TO 18, AND OCTOBER 19 TO DECEMBER 3, 1934

MONTH OF EMERGENCE OF *A. ridibunda*	MATERIAL PARASITIZED OCT. 1 TO 18, 1934 — 17 LOTS		MATERIAL PARASITIZED OCT. 19 TO DEC. 3, 1934 — 10 LOTS	
	Number	Percent	Number	Percent
October, November, December	16,477	93.13	5,412	25.2
March and April	3	.02	8,007	37.3
June	24	.14	804	3.8
July	1,152	6.51	3,455	16.1
August	31	.17	370	1.7
September and October	6	.03	3,405	15.9
	17,693	100.00	21,453	100.00

As a rule, when *Alysia ridibunda* parasitized blowfly larvae in the spring or early in the fall most of the parasites emerged in from 19 to approximately 40 days. However, in large lots of parasitized material a small percentage of parasites would remain dormant for many months. For instance, from a lot of material exposed to *A. ridibunda* May 12, 1934, 5,946 parasites emerged in from 19 to 32 days thereafter, and 12 specimens issued after a period of 160 days. From several lots of larvae parasitized September 14 to 17 a small percentage of *A. ridibunda* emerged 330 days later.

When parasitization took place late in the spring or early in the summer the developmental period was lengthened considerably, apparently because of an aestivation period during the hot weather.

A comparison of the emergence of *Alysia ridibunda* from material parasitized from October 1 to 18 and from October 19 to December 3, 1934, is shown in Table I. From 17 lots of larvae parasitized from October 1 to 18 a total of 17,693 *A. ridibunda* emerged, 93.1 per cent of which issued in approximately 20 to 40 days. A small emergence occurred at various times in the spring and summer, and 0.03 per cent emerged in October, 1935. The longest developmental period in this group was 345 days.

From 10 lots of larvae parasitized from October 19 to December 3 a total of 21,453 *Alysia ridibunda* emerged; 25.2 per cent of these emerged in November and December and 37.3 per cent issued in March and April. A total of 3,405 or 15.9 per cent of the parasites remained dormant and emerged in September and October, 1935, representing a developmental period of over 300 days. The maximum period recorded was 350 days.

RELEASE

A total of 50,221 *Alysia ridibunda* were liberated in colonies of from 25 to several hundred, but the average release constituted about 80 specimens, approximately equally divided as to sex. Releases of the parasite began in October, 1934, and 22,557 specimens were turned loose in 309 colonies during October, November, and December. The liberations in the spring of 1935 were made principally in spots where small numbers had been released before. They were made along the highways radiating out from Uvalde to a distance of 25 miles to the north, 20 miles to the south, 14 miles to the east, and 15 miles to the west. Colonizations were made in various types of environment and especially where small animal carcasses might be present. This parasite did not appear to be a strong flier, hence the small releases were made and scattered over several miles so as to increase the chances that the parasites would find host material in carcasses as soon as possible.

RECOVERY

To determine if the parasite had become established, a total of 102 four-ounce meat baits were exposed in various parts of Uvalde County from April 18 to June 4, 1935. These meat baits were placed on 2 inches of sand in pint mason jars, and after an exposure period of from 5 to 9 days in the field they were brought to the laboratory and the emergence of flies and parasites recorded from each jar. Over 90 per cent of the larvae in the meat baits were those of *Sarcophaga* and *Lucilia*, although some of the baits were infested with a small percentage of *Cochliomyia macellaria* and *Synthesiomyia nudiseta* (V. d. W.). A total of 6,835 *Alysia ridibunda* emerged. This was 39.2 per cent of the total emergence of flies and parasites. *Brachymeria fonscolombei* (Duf.), the indigenous blowfly parasite, accounted for a parasitization of 7.1 per cent of the blowfly larvae. *A. ridibunda* was recovered from 70 baits, and the parasitization ranged from 1 to 100 per cent in the various baits. It

was clear that the parasite had made a remarkable increase in only a few months' time.

Activity of *Alysia* throughout the season was secured by exposing 10 meat baits at intervals of 10 days in a native pasture near Uvalde, Tex., from April 1 to September 21, 1935. These baits were exposed in the same location in each series and were spaced approximately one-tenth of a mile apart. In table II is recorded the emergence of flies and parasites from each series of baits. Only *Sarcophaga* and *Lucilia* flies are recorded, although a small infestation of other blowflies occurred.

TABLE II

NUMBER AND PERCENTAGE OF BLOWFLIES AND PARASITES WHICH EMERGED FROM EACH SERIES OF TEN 4-OUNCE MEAT BAITS EXPOSED AT UVALDE, TEXAS, APRIL 1 TO SEPTEMBER 21, 1935

SERIES No.	DATE EXPOSED	FLIES EMERGED				PARASITES EMERGED			
		Sarcophaga		*Lucilia*		*Brachymeria fonscolombei*		*Alysia ridibunda*	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent
1	April 1	968	63.6	98	6.5	237	15.6	218	14.3
2	April 11	639	64.0	3	.3	.....	.....	356	35.7
3	April 21	746	40.3	14	.8	428	23.1	661	35.8
4	May 1	384	48.0	35	4.4	37	4.6	344	43.0
5	May 11	129	43.1	59	19.7	11	3.7	100	33.5
6	May 21	222	20.8	15	1.4	67	6.2	766	71.6
7	June 1	300	44.9	.....	.....	117	17.5	251	37.6
8	June 11	147	35.7	60	14.5	9	2.2	196	47.6
8	June 21	44	5.2	9	1.1	58	6.9	734	86.8
10	July 1	9	2.1	.....	.....	207	47.6	219	50.3
11	July 11	22	6.6	.....	.....	292	87.4	20	6.0
12	July 21	22	12.8	9	5.3	125	73.1	15	8.8
13	Aug. 1	41	16.8	20	8.2	181	74.2	2	.8
14	Aug. 12	163	37.4	.....	.....	262	60.1	11	2.5
15	Aug. 22	109	50.2	.....	.....	108	49.8	.....	.....
16	Aug. 31	72	40.2	.....	.....	107	59.8	.....	.....
17	Sept. 11	62	87.3	2	2.8	7	9.9	.....	.....
18	Sept. 21	82	51.2	.....	.....	2	1.3	76	47.5
	Total	4,161	38.8	324	3.0	2,255	21.1	3,969	37.1

A total of 3,969 *A. ridibunda* were reared from the baits, comprising 37.1 per cent of the total flies and parasites. *Brachymeria fonscolombei* accounted for a parasitization of 21.1 per cent of the blowfly larvae. The percentage of parasitization of blowfly larvae by *A. ridibunda* continued high until the exposure period of July 11 to 21 and thereafter showed a distinct decline until August 22, when no parasitism was indicated for 30 days. The last series exposed September 21 showed a 47.5 per cent parasitization by *A. ridibunda*. The inactivity of the parasite during the hot part of the summer indicated an aestivation period. *B. fonscolombei* did not reach its full effectiveness on blowfly larvae until midsummer, when the numbers of *A. ridibunda* decreased.

The parasites were observed on all kinds of carrion, including the carcasses of sheep, goats, chickens, cats, rabbits, fishes, and snakes. They were caught by the dozens in liver-baited fly traps, and it was evident that they had built up a tremendous population by July 1.

Alysia ridibunda appeared to be reducing the number of *Sarcophaga* flies. The population of these flies, as indicated by catches in a liver-baited fly trap, showed a much lower incidence from April 1 to June 30, 1935, than in any year during the operation of the trap from 1931 to 1937, inclusive. Approximately one-half as many *Sarcophaga* were caught in 1935 as the next lowest year. It is possible that some other factor brought down the number of *Sarcophaga*, but it is clear that *A ridibunda* caused the death of considerable numbers of the larvae of these flies.

In the spring of 1936 it was evident that the parasite was not so abundant as in 1935. The seasonal status indicated an average of only 1 per cent parasitization of blowfly larvae from April 1 to September 22, and the species was recovered in only 10 baits. A higher percentage of infestation was indicated in a cottontail rabbit carcass in April, when 15.7 per cent of the blowfly larvae yielded *A. ridibunda*. In 1937 no recoveries of the parasite were accomplished and only two adult specimens were observed. The regular exposures of meat baits were discontinued in July of that year, but frequent examinations of carcasses failed to reveal any parasites. In June, 1938, three adult parasites were found in a fly trap.

HOST PREFERENCES

To determine the host preference of *Alysia ridibunda* on blowfly larvae in the field, 23 meat baits, ranging in size from 4-ounce pieces of beef to jack rabbits, were exposed in nature in May and June, 1935. When the larvae in the carrion were mature they were segregated according to genera or species and the emergence of flies and parasites was recorded from each group. A total of 11,650 larvae were separated in these tests. In Table III are shown the number and percentage of flies and parasites that emerged from each group of larvae.

From 6,553 *Sarcophaga* larvae an emergence of 80.9 per cent of *Alysia ridibunda* and 1.8 per cent of *Brachymeria fonscolombei* occurred. *A. ridibunda* emerged from 22 of the groups of *Sarcophaga* larvae and the rate of parasitization ranged from 4 to 99 per cent in the various tests.

From 4,791 *Lucilia* larvae there was an emergence of 10.4 per cent of *Alysia ridibunda* but no *Brachymeria fonscolombei* emerged. *A. ridibunda* emerged from 16 of the *Lucilia* tests and the rate of parasitization ranged from 0.3 to 51 per cent.

There was no emergence of parasites from larvae of *Synthesiomyia nudiseta* or *Cochliomyia macellaria*. This corroborates numerous tests in the laboratory.

According to these tests it appears that *Alysia ridibunda* goes through its life cycle in *Sarcophaga* larvae better than in the other species. It is not known whether the parasite distinguishes between various species of larvae in a carcass or oviposits indiscriminately in whatever larvae

are available. Promiscuous oviposition probably results in death of both parasite and host.

Alysia ridibunda was frequently observed working on dipterous larvae in human excrement and has been reared from larvae collected in this medium. Howard (1900) collected the parasite on human excrement. In a host test in March, 1935, the parasite was reared from *Sarcophaga haemorrhoidalis* Meig. reared on human excrement. The parasite was never observed on cattle droppings and when confined in cages seemed to have little interest in larvae in dung.

Alysia ridibunda was used in many tests on the larvae of the screwworm fly (*Cochliomyia americana* C. & P.). When the parasite was confined with third-instar screwworm larvae no parasites issued, but the fly emergence was reduced. *A. ridibunda* worked among pieces of beef infested with larvae of *Sarcophaga* and *C. americana* and emerged from the former but not from the latter.

TABLE III

EMERGENCE OF FLIES AND PARASITES FROM DIFFERENT GENERA AND SPECIES OF BLOWFLY LARVAE IN 23 MEAT BAITS EXPOSED IN THE FIELD DURING MAY AND JUNE, 1935, UVALDE, TEXAS

LARVAE	EMERGENCE					
	FLIES		*Alysia ridibunda*		*Brachymeria fonscolombei*	
	Number	Percent	Number	Percent	Number	Percent
Lucilia spp.	4,291	89.6	500	10.4	.....	.....
Sarcophaga spp.	1,135	17.3	5,298	80.9	120	1.8
Synthesiomyia nudiseta	255	100.0	.....	.....	.....	.....
Cochliomyia macellaria	51	100.0	.....	.....	.....	.....

In May, 1935, a jack rabbit that had died from a screwworm infestation was exposed to *Alysia ridibunda* in a cage. From 69 third-instar larvae of *Cochliomyia americana* collected no parasites emerged and only 43.5 per cent of the puparia yielded flies. From 56 larvae taken from the wound prior to exposure to the parasites 100 per cent emergence of the flies resulted.

Two guinea pigs were infested with larvae of *Cochliomyia americana* in June, 1935, and adults of *Alysia ridibunda* were confined with one of the animals. The parasites worked vigorously over the wound, thrusting their ovipositors into the larvae. Thirty-two larvae were collected, but no emergence of flies or parasites occurred. In the check case 100 per cent of the larvae produced flies.

A study of the fate of the host and parasite revealed that *Alysia ridibunda* is capable of thrusting its ovipositor through the body wall of *Cochliomyia americana* larvae and depositing eggs, but that both host and parasite eventually die. In a few instances the parasite larvae developed to the second instar before death resulted. Disintegration

of the fly pupae took place rapidly, and at the end of the sixth day after parasitization nothing remained in the puparia except a dry residue adhering evenly to the walls.

The examination of approximately 300 cases of myiasis in domestic animals during the time that adults of *Alysia ridibunda* were active on carrion failed to reveal the parasite working on wounds in nature. Larvae collected from 241 screwworm cases in domestic animals did not yield any parasites. It appears that the parasite does not exert any degree of control on the screwworm in nature.

DISPERSION FROM RELEASE AREA

Two surveys were made to determine if the parasite had migrated beyond the release area. The method employed was the exposure of meat baits in each cardinal direction from Uvalde.

In the first survey, conducted October 7 to 12, 1935, 150 meat baits were exposed. No *Alysia ridibunda* were recovered to the south or east, but to the north, in the rugged escarpment of the Edwards Plateau, two recoveries were made, one of which was 8 miles beyond the release area. Toward the west the parasite was recovered in the farthermost bait exposed, which was 13 miles from the last point of liberation.

The second survey, conducted June 11 to 20, 1936, showed the heaviest parasitization, (7.4 per cent of the blowfly larvae) to be in a westerly direction, and the parasite was recovered 27 miles from the release area in that direction. Only six parasites were recovered to the north, none to the south, and five to the east—all within the release territory.

These two surveys indicated that *Alysia ridibunda* had moved westward into a rolling, short-brush type of country with better success than it had in the other directions with their different ecological environments.

TEMPERATURE AND RAINFALL DURING THE EXPERIMENT

The parasite *Alysia ridibunda* remained established for 4 years. It was most active during the months April to July, inclusive. During the first year of its establishment, 1935, it was present in far greater numbers than the following years. The underlying causes for the diminution in the numbers of the parasite are probably climatic, although it is not possible to point to any set of conditions with the certainty that they were responsible. A review of the meteorological data shows that from April to July, inclusive, the mean temperature at Uvalde, Tex., was identical for 1935 and 1936, i. e., 77.1° F., which is 1.3° below average. The rainfall during these months in 1935 was 30.2 inches, over three times the normal precipitation. In 1936 the rainfall was 10.8 inches, 1 inch above average. The average number of days with measurable precipitation (0.01 inch or above) is 16. In 1935 this was 34 days and in 1936, 26 days.

The annual temperature was 69.8° F. in 1935, 68.4° in 1936, 69.6° in 1937, and 71.0° in 1938. The annual rainfall was 41.8 inches in 1935, 27.2 inches in 1936, 16.7 inches in 1937, and 14.3 inches in 1938. The

maximum temperature was 100° in 1935 and 108° in 1936, and the minimum, 18° in 1935 and 19° in 1936.

The areas in New Mexico and Arizona where *Alysia ridibunda* were collected have hot summer months with maximum temperatures well above 100° F. and usually as high as 110° or above. The winters are mild to cold with extreme low temperatures of about 5° F. and ranging from 10° to —7°.

Alysia reached its highest population in Uvalde during the period with rainfall much above the average and much higher than the normal rainfall in the New Mexico and Arizona areas. The parasite diminished greatly in 1936, a year when the average rainfall was only slightly above normal in Uvalde, and neared extinction in 1937 and 1938, when the rainfall was far below normal yet compared favorably with the rainfall in the New Mexico and Arizona areas. There are probably other factors that influenced the species, but they are not easily discernible. Competition between this species and *Brachymeria fonscolombei* has been considered, but *Brachymeria* occurs with *Alysia* in New Mexico and Arizona.

SUMMARY

Alysia ridibunda Say, a blowfly parasite discovered in southern Arizona and New Mexico but occurring generally over the eastern portions of the United States and in parts of Canada, was introduced into Uvalde County, Tex., in 1934 and 1935. Laboratory rearing showed the duration of the immature stages to be from 19 to 350 days. A total of 50,221 adults of this parasite were reared in the laboratory and released in the fall of 1934 and the spring of 1935. By July 1, 1935, the insect had built up a tremendous population and was found on practically every carcass and small piece of carrion. The parasitization of blowfly larvae by *Alysia ridibunda* ranged up to 100 per cent, with an average of 37.1 per cent from April 1 to September 21, as indicated by exposure in pint jars of 4-ounce meat baits infested with blowfly larvae. During 1936 the parasite diminished greatly in numbers, in 1937 only two specimens were seen, and in 1938 only three were observed.

In 1935 the parasite emerged from 80.9 per cent of *Sarcophaga* larvae and from 10.4 per cent of the *Lucilia* larvae collected in the field in that year. This indicated that *Sarcophaga* was a preferred host. No emergence occurred from other species of blowfly larvae. The parasite oviposited on larvae of the screwworm (*Cochliomyia americana*) in the laboratory, but both host and parasite succumbed. The examination of approximately 300 cases of myiasis in domestic animals failed to reveal the parasite working on larvae in wounds, but adults oviposited

in larvae of *Cochliomyia americana* in wounds on guinea pigs in the laboratory and both the host and parasite larvae died.

Dispersion from the release area in 1935–36 proceeded farther westward than in other directions, and greater numbers occurred in that direction. The point of recovery farthest from the point of release was 27 miles to the west.

The causes for the remarkable increase in the population of *Alysia ridibunda* shortly after its release and the subsequent marked decrease are not fully understood.

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STATISTICAL TECHNIQUE IN AGRICULTURAL RESEARCH, by D. D. Paterson. ix+263 pp. 1939. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York. Price $3.00.

Until recently there was a regrettable scarcity of books dealing with modern statistical methods in biology. The present volume is one which should appeal to the agriculturist, since the examples chosen are taken mainly from field experiments and the question of design of complex field trials is discussed in full detail. It is a smaller volume than the usual text, the conciseness being largely due to the use of a minimum of examples and to the exclusion of unworked examples or exercises. Diversity and repetition of examples are, of course, very useful aids to understanding in statistics, but the lack of these features should not detract from the book's attractiveness as a text since they can be easily supplied by the instructor. As a manual for self-instruction the economy is perhaps somewhat more doubtful. As it stands, however, the book includes a complete description of modern biometrical methods with careful attention to matters of interpretation and to questions of experimental procedure. As is usual, no special mathematical training is presupposed, and a developmental rather than a mathematical approach is used.

The symbolism differs in some respects from that commonly employed in connection with Fisherian methods. This is, of course, ordinarily unimportant, but in one connection, at least, the change is quite unfortunate. The symbol, σ, is used for the standard deviation of the sample instead of the unknown population standard deviation, and no symbol is provided for the latter quantity. In fact, in general, the distinction between population parameters and sample estimates is not emphasized, a fact which must certainly hamper the student's understanding of the fundamental logic of statistics. It is felt that a little more attention to the basic mathematical problems solved by the *Technique* could profitably be incorporated without sacrificing the orderliness, clarity, and conciseness of treatment which make the book so attractive.

The Analysis of Variance method is introduced early, following a first chapter on General Principles, and most of the remainder of the book is devoted to its logical extension, to regression, analysis of covariance, and complex experimental arrangements. There are also chapters on goodness of fit, diagrams, and special statistical considerations in connection with serial and perennial crop experiments. The reader is also provided with a Selected Bibliography, an Appendix of statistical tables, and Index.—C. W. C.

MITOTIC RESPONSE OF ROACH HEMOCYTES TO CERTAIN PATHOGENES IN THE HEMOLYMPH

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During a series of determinations of percentages of mitotically dividing cells in hemolypmh of normal (6) and molting (7) specimens of the roach, *Blatta orientalis*, a number of individuals with high bacterial populations in the hemocoelic fluid were encountered. These insects were isolated and samples of their hemolymph were more closely examined. Mitotically dividing cell (M. D. C.) counts were found to be consistently higher than in the normal uninfected roaches. This paper is a report of these findings, accompanied by results from some attempts to inoculate normal roaches with these pathogenic bacteria.

According to Paillot (1), bacteria are found in the alimentary tract and body fluids of many insects; and Pospolov (2) is even of the opinion that every insect possesses its specific *Coccobacillus*. Tauber and Yeager (4) have previously recorded the presence of bacteria in hemolymph of the oriental roach, as well as in hemolymph of other insects (3, 5), but no references to study of karyokinetic reaction of this species' hemocytes during infections has been found.

The technique for making M. D. C. counts, as modified from the original method by Yeager and Tauber (9), has been fully described elsewhere (6) and needs no repetition here. The average M. D. C. percentage from normal *Blatta orientalis* is 0.186, with a range from 0.116 to 0.250 per cent (6). The maximum individual count for normal specimens was never found to exceed 0.5 per cent in nearly 600 different individuals examined.

Successful attempts to inoculate normal animals with the pathogenes were effected. Normal stock roaches were segregated and examined at least three times over a period of a week for the presence of bacteria in the hemolymph. If M. D. C. counts from these selected animals were within normal limits, they were then infected. This was brought about by inserting the point of a flame-sterilized dissecting needle into an infected animal or into a 36-hour broth culture and then transferring the

wet inoculum into the body cavity of the normal insect, usually through one of the dorsal abdominal conjunctivae.

RESULTS

Two distinct types of bacteria were found in hemolymph of *Blatta orientalis*. The two pathogenes were never found together in the same insect. One bacterium was a micrococcus; the other a rod-shaped form. Culture characteristics of the former showed it to be *Staphylococcus albus* (8); but the latter has been difficult to culture in artificial media and, so far, has not been identified.

Six specimens infected with the coccus were isolated. Pertinent data concerning them are included in the following table:

TABLE I

SUMMARY OF DATA FROM ROACHES INFECTED WITH *Staphylococcus albus*

Animal Number	Number Counts Made	Number Days Observed	Range of M. D. C. Counts (Percent)
633	16	23	0.40–2.35
636	10	12	0.20–1.55
643	2	2	0.60–0.80
743	10	11	0.40–1.50
754	12	13	0.45–1.15
756	10	10	0.25–1.00

TABLE II

DATA FROM ROACHES INFECTED WITH SHORT RODS

Animal Number	Number Counts Made	Number Days Observed	Range of M. D. C. Counts (Percent)
645	16	16	0.15–1.25
656	15	15	0.20–3.10
662	10	10	0.30–1.20
666	19	25	0.15–2.45
667	14	18	0.45–1.35
683a	3	3	0.55–1.45
734	3	3	0.60–1.40
736	8	8	0.75–1.35

In most cases the period of observation was short since the animal's condition was not discovered until the infection was quite far advanced.

One normal animal, No. 752, inoculated by needle puncture with bacteria from one of the infected roaches reached a M. D. C. count of 1.70% within nine days after infection set in. All cases were terminated by death.

In Figure 1 are plotted two curves: that from insect No. 633 whose infection was present at the beginning of observation; and that from No. 752 whose infection was the result of a needle inoculation.

Eight insects afflicted with the unidentified rod form were found. Data are summarized in Table 2.

Figure 2 graphically presents the course of the counts from No. 656 of Table II. It also includes the trend of M. D. C. determinations from No. 660 which was artificially infected, as described above.

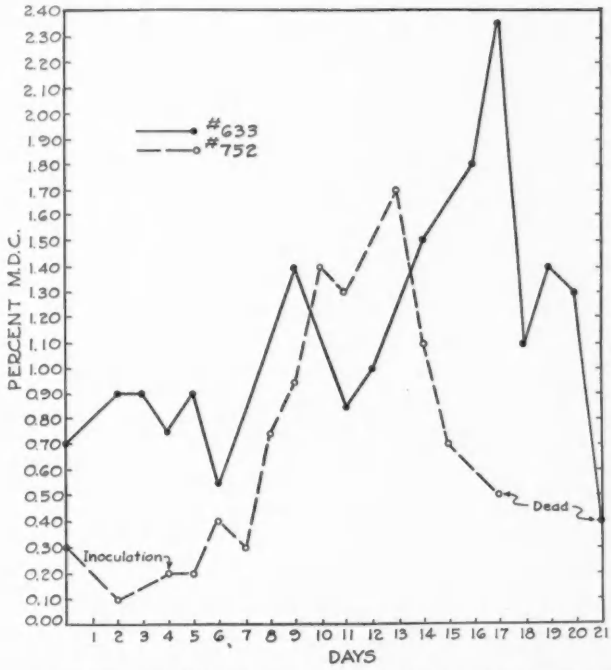

Figure 1. Curve (solid line) from roach No. 633 infected with *Staphylococcus albus* when isolated from stock colony, showing variations in mitotically dividing cell percentages over a period of 21 days; and from animal No. 752 (broken line), a normal roach, inoculated with this same organism. Solid dots and rings indicate times when samples of hemolymph were taken.

In addition to Nos. 752 and 660 which were artificially infected with the coccus and the rod, respectively, other normal roaches were inoculated in the same manner. Nos. 752a and 752b inoculated with hemolymph containing *Staphylococcus albus* reacted to produce peak M. D. C. counts of 1.95% and 1.70%, respectively; Nos. 748 and 748a, inoculated with the pathogenic rod, had maximum mitotic counts of 1.05% and 2.5%, respectively. As a control to the artificial inoculation method, 10

normal roaches were punctured with the flame-sterilized needle to check whether or not the insertion of the needle point would carry with it any bacteria which might be on the surface of the roach. No infections resulted in the controls.

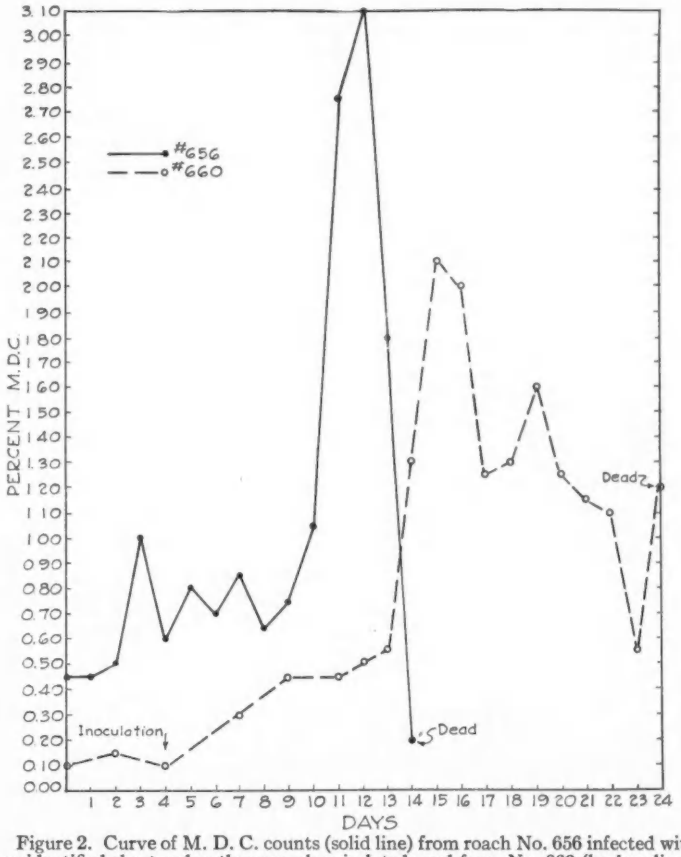

Figure 2. Curve of M. D. C. counts (solid line) from roach No. 656 infected with an unidentified short rod pathogene when isolated; and from No. 660 (broken line), a normal roach, inoculated with the same bacterium.

To check even further the pathogenicity of this strain of *Staphylococcus albus*, samples of the infected hemolymph were plated out on agar. From the resulting colonies pure cultures were isolated and grown in nutrient broth. Artificial inoculation of ten normal roaches was then attempted by dipping a sterilized needle into a 36 hour broth culture and inserting the needle into the body cavity of the insect. Of the ten

attempts, eight proved successful and produced maximum M. D. C. counts of 1.75%, 0.95%, 0.80%, 1.95%, 2.05%, 1.05% 1.45%, and 0.95%. In general the course of M. D. C. counts from these specimens followed the trend shown in Figure 1.

In all cases of natural and artificial infections, observations were terminated by death. The longest period of observation for any infected individual was 41 days, but the average was slightly less than 17 days. Normal insects were often kept over 100 days (maximum 132 days) under the same types of conditions and were discarded while still alive.

DISCUSSION

If the maximum mitotically dividing hemolymph cell percentage (0.50%) in normal roaches is compared with the maximum found in infected animals (shown in Tables I and II and Figures 1 and 2), it is quite apparent that the presence of the two pathogenes in the hemolymph is definitely stimulatory to mitosis of circulating hemocytes. To a certain extent this response is suggestive of the hemopoietic activity of the bone-marrow of vertebrates in the course of certain types of infection. Since some of the roach hemocytes are phagocytic, it would be to the animal's advantage to increase the number of phagocytes by mitosis under such conditions.

Infection with either *Staphylococcus albus* or the rod pathogene is accompanied by an orderly set of symptoms. Food is taken in small quantities; movements are slow and feeble; paralysis of a progressive, anteriorly moving type manifests itself; spasmodic jerking of the whole body occurs; the body becomes arched, with the head folded under the pronotum; and eventually death occurs. In no case where the diseases were recognized was there recovery. Recognition, however, was never easy until the number of bacteria was already quite high. It may be that the animal has a defensive mechanism against slight infections, but is unable to combat the disease after the bacterial population reaches a certain level.

Internally, the increase in number of bacteria is associated with other effects. Hemocytes become vacuolated, stain more easily and more deeply, and become "ragged," with irregular edges. In the final stages of the diseases, cytolysis of hemolymph cells becomes very noticeable. At death the hemolymph is filled with cellular fragments, is thick and milky white with bacteria. In a few cases, the hemocoelic fluid became yellowish or a light orange-brown after death.

In some victims, especially with reference to the rod pathogerm, a peculiar manifestation was noted. Toward the end of the course of infection, the conjunctival folds at the various joints of the body would rupture and the thick, white hemolymph oozed out of the break. This was particularly true at the joints of the meta-thoracic legs and in the folds between the dorsal abdominal sclerites.

Both the rod and the *Staphylococcus albus* infections could be easily transferred to normal animals. The increase in the number of bacteria when inoculated into a healthy roach was very rapid. Within a few days an increase in dividing hemolymph cells would follow.

Just how the two bacteria make their entrance into the hemolymph of normal roaches is not known. The growth and eating habits of this roach, however, suggest two possibilities. After an insect molts, the exoskeleton is soft, easily damaged, and not at all as protective as the sclerotized covering which develops later. Under crowded conditions, it may well be that a newly molted roach comes in contact with bacteria on the body surface of a dying, infected specimen, or comes in contact with a surface or another roach which is carrying the pathogenic agents. In either case the bacteria are in a position to penetrate the delicate, newly-exposed exoskeleton, or to pass through any breaks in the surface, and thus enter the hemolymph. The other possibility is related to the cannibalistic habits of roaches. Often they will eat the bodies of dead, weak, or disabled individuals. If such victims were infected with the causative organisms, the bacteria would enter the digestive canal and might enter the hemocoele by penetrating the gut wall.

SUMMARY AND CONCLUSIONS

1. Two bacteria, *Staphylococcus albus* and an unidentified short rod, have been found in the hemolymph of the roach, *Blatta orientalis*.

2. The presence of the two pathogenes was found in all 14 of the diseased insects to be associated with high mitotically dividing cell counts in the hemocytes. This mitotic reaction is perhaps similar in its function to the protective increase of leucocytes in vertebrate animals. M. D. C. counts as high as 3.10% were encountered in infected animals. This is much higher than the maximum (0.50%) M. D. C. percentage from normal roaches.

3. Symptoms of the infection include loss of appetite, sluggishness, and paralysis. In some cases, breaks in the conjunctivae would occur and allow the thick, white hemolymph to escape. Internally, the hemocytes undergo vacuolation with eventual disintegration.

4. Both the coccus and the rod infections were easily transmitted to normal uninfected specimens, either by direct transfer of infected hemolymph or by way of pure cultures growing in a broth medium, with a subsequent rise in the M. D. C. counts as the infecting organisms became more numerous. The rod-shaped organism is perhaps the more virulent of the two bacteria.

5. It is suggested that the infections are spread from insect to insect by contact—especially to newly molted individuals—or, because of cannibalistic tendencies, by actual ingestion of bacteria which may penetrate the gut wall.

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ELEMENTS OF STATISTICAL REASONING, by ALAN E. TRELOAR. xi+261 pp., 46 figures and 49 tables. 1939. Published by JOHN WILEY AND SONS, INC., 440 Fourth Ave., New York. Price $3.25.

Elements of Statistical Reasoning is intended primarily for biologists who lack special mathematical training. It is by no means a complete account of modern statistical techniques used by biologists, but rather, as its title would suggest, a thorough treatise on the mathematical and logical principles underlying the more elementary statistical tests. The use of very few examples and lack of treatment of the analysis of variance and covariance, curvilinear regression, and experimental design are features which might be mentioned to show that it is a book of principles rather than one of methodology. It will therefore not prepare the biologist for the wide variety of statistical problems which he may expect to encounter, but will serve very admirably to give him a broad outlook on biological variation and a thorough introduction to fundamental concepts.

Outstanding among the book's merits is the way in which statistical formulae are introduced and explained. First, the need for the proposed statistic is discussed along with the logical requirements which it should fulfill. The formula is then built up step by step and alternative formulae are dismissed as illogical or otherwise undesirable. Finally, the statistic so derived is visualized by the aid of geometrical diagrams and its uses and limitations are carefully discussed. The author obviously believes that the biologist can acquire a reliable working knowledge of statistics only after complete mastery of the underlying mathematics and has devoted his best efforts and skills to this purpose. The writing itself is quite forceful and enlivened by numerous historical anecdotes and quotations.

Most of the statistics described in this book are those of "large sample theory" while "small sample methods," which are at present more popular with biometricians, receive little attention. In the reviewer's opinion, the author expresses undue skepticism in his view that small sample theory and the use of the "degrees of freedom" concept are disadvantageous for the purpose of teaching elementary statistics. Even if increased precision were not gained through their use, it would still seem that the concepts are essential to an understanding of principles of arrangement and analysis of complex experiments for which, ultimately, the biologist must be prepared. It is hoped that these topics will receive the same careful elucidation in a second volume which is now contemplated.

There are a few novel features among the contents; the chapter titles are as follows: Numerical Description—The Law of Frequency Distribution—Typical Values—The Measurement of Variation—Moments and Distribution Characteristics—The Normal Curve—Bivariate Distribution and the Coefficient of Correlation—Rectilinear Regression—Residual Variation—Errors of Random Sampling—Sampling Errors of the Correlation Coefficient—Proportions and Probability—The Proportions of Vital Statistics—Sampling Errors of Proportions—The Measurement of Frequency Discordance—Independence and Bivariate Tables of Frequency. Selected Formulas and Tables are included in five appendices. An index is supplied, but unfortunately there is no list of reference works of any kind.—C. W. C.

A COMPARATIVE STUDY OF THE LARVAE OF SIX SPECIES OF SILPHA[1]

(Coleoptera, Silphidae)

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Observations are here presented that were made during a study of the larvae of six species of the genus *Silpha*. Three species, *S. americana* L., *inequalis* Fab., and *noveboracensis* Forst., were associated with the adult stage by the writer by processes of rearing. The other three species, *surinamensis* Fab., *ramosa* Say, and *lapponica* Hbst. are determined specimens lent to the writer for study by the U. S. National Museum.

BIOLOGICAL OBSERVATIONS

Although the primary objective in the rearing operations was that of associating larval and adult stages of *americana*, *inequalis* and *noveboracensis*, some biological observations were inevitable and certain of these will be included. The specimens used in rearing attempts were confined to the three last-mentioned species; all references to biological notes will pertain to these unless otherwise indicated. The investigations were carried on at the University of Maryland, College Park, Maryland, May 3 to September 1, 1939.

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FIELD OBSERVATIONS

For the purpose of attracting adult silphids a freshly killed cat was placed in a sheltered place near the edge of a woods on May 3. Four days later adults of all three species were first noticed on and around the carcass feeding and mating; *americana* being less numerous than the other two. By May 10 practically all of the beetles had disappeared. On May 12, small silphid larvae, varying in length from 5 to 8 mm., were observed around the carcass. On May 16, two other similar attrahent baits were deposited; in this case, also, it was four days later when adult silphids were first noticed in any numbers near the carrion. On this date *americana* was present in greater numbers than either of the other two species. Small silphid larvae were first found under the carrion on May 26.

The adults and larvae of all three species apparently prefer the moist conditions under a carcass in contact with the soil; at least, they were always found in greater numbers in these locations. They were occasionally seen in the decomposed carcass and frequently among the hair, in the trash and leaves nearby. Both adults and larvae were observed feeding on decaying flesh, usually near softer parts and excretions. However, the larvae feed principally on the dried remains of hide, sinew, shreds of meat, etc., which is all that is left after the dipterous larvae have finished with the carcass. On two different occasions, *americana* larvae were seen feeding unprotected on exposed shreds of dried meat during a heavy rain. Both larvae and adults seek cover when exposed to the force of the direct rays of the sun. On cloudy days they are much more in evidence, crawling over and around the carrion. When an infested carcass is disturbed, adults and larvae quickly hide in nearby trash, etc.; *americana* moves much faster than either of the other two species.

It would seem that carrion has the greatest attracting powers for the adults after it reaches a certain state of decomposition. According to the writer's observations, that is about four days after the deposition of a freshly killed carcass. After this state has been reached, the dipterous maggots literally take possession and adult silphids disappear.

REARING OBSERVATIONS

In associating silphid larvae with their adult forms by rearing, various types of cages were used. All rearing operations

were carried on in a tightly screened insectary; each cage or group of cages was placed in an individual screened container.

The mortality in most of these cages was very high; in fact, only two larvae were carried through to the pupal stage, one of which reached the adult stage. The most successful type of cage proved to be a tightly screened one covered entirely with gauze; a layer of soil covered the bottom. A freshly killed guinea pig was placed in each of these cages accompanied by about twelve adult beetles. Each cage was furnished with a water container; it is important that water be kept before the beetles and larvae.

Much interference and trouble was caused by fly larvae, both in adult and larval cages; it seemed almost impossible to exclude them even from screen cages covered with gauze. The maggots would become so numerous in the cage and the accompanying slime so abundant that the silphids would soon die. It is thought by Steele (14) that adult *Necrophorus orbicollis* Say, *tomentosus* Web., *Silpha americana* L. and *noveboracensis* Forst. probably prefer maggots to carrion as food. The writer did not experiment at all extensively along these lines; however, upon two different occasions, adult beetles of *Silpha americana*, *inequalis* and *noveboracensis* were isolated in containers and denied food for twenty-four hours, after which time live maggots were deposited in each container. In both cases only *americana* fed upon the maggots; an adult would viciously seize a maggot and devour it within five minutes time. Silphid larvae tested similarly did not attack the maggots. Goe (5) speaks of adult *inequalis* readily eating freshly killed flies. Maggots may be an important item in the diet of silphid adults; however, the writer found that the beetles lived about as long in cages containing uninfested meat as they did in those containing meat infested with maggots. A cage of *noveboracensis* adults lived twenty days on maggotless carrion; another similar group lived twenty-four days in a cage containing infested carrion; *inequalis* lived fifteen days on maggotless carrion as compared with a similar group which lived eighteen days on infested carrion; *americana* lived seventeen days on maggotless carrion as compared with a similar group, which lived nineteen days on infested meat.

In no instance, either under field conditions or in rearing cages, was an egg found on or in carrion; in all cases observed the egg was laid either on top of or just beneath the soil surface. In one cage an egg was found sticking to the screen side of the cage.

A series of adult females of each species was dissected and counts were made of the ovarian eggs. *Inequalis* averaged nine, *noveboracensis* eight, and *americana* ten. The incubation period for the eggs of all three species in the rearing cages was about six days.

Silphid larvae, when closely confined together, have a tendency to be cannibalistic. The larger ones occasionally attack the smaller ones; they quickly eat away the softer sternal regions and devour the body contents.

The *inequalis* and *noveboracensis* larvae which were successfully reared to the pupal stage made smooth, oval, earthen cells in the bottom of the cage. The *inequalis* larva was about 7 mm. long and 2.7 mm. wide when collected in the field; there was an ecdysis on May 21 and another on May 23. The larva entered the prepupal stage on May 30 and the pupal stage on June 1. The adult emerged June 9. The *noveboracensis* larva was about 13 mm. long and 6 mm. wide when collected in the field. The first change was noticed when the larva entered the prepupal stage on May 25. The pupal stage commenced May 29; the pupa died on June 1.

DESCRIPTION OF LARVAE

The material on which the following descriptions are based is in the U. S. National Museum. Microscope slide mounts were made of the head appendages, external and internal mouthparts of all species studied. All measurements were made with an ocular micrometer.

GENERIC DESCRIPTION OF LARVAE

Body campodeiform; wider than depth from dorsum to sternum in all body regions; entire length of dorsum of body segments marked with a narrow, shallow, central, longitudinal impression which in *inequalis*, *noveboracensis* and *surinamensis* is light-colored; in *americana*, *ramosa* and *lapponica* the color is similar to that of rest of dorsum.

Head broader than long; sclerotized external spots of distal ends of *dorsal tentorial* arms (fig. 43, DT) contiguous with frontal sutures and more or less in line with antennal sockets; *dorsal occipital region* furnished with two small, strong setae on each side.

Mandible (fig. 38) with broad, sub-triangular base tapering to posterior region of the strong and gradually tapering incisor lobe, apex bears two teeth which are acute and usually slightly serrate; mandible with a small seta at base of incisor lobe, adjacent to outer margin, on ventral surface; posterior, outer, lateral base of mandible, on dorsal surface, with one strong seta accompanied by several smaller ones.

Clypeo-frontal suture distinctly defined only at lateral margins; *clypeo-labral* suture distinct; *clypeus* broadly trapezoidal, broader posteriorly, with posterior lateral angles sharply defined by heavily sclerotized carinae of clypeo-frontal suture.

Labrum bilobed, sub-trapezoidal with anterior angles rounded, each posterior lateral angle bears a light-colored L-shaped marking (fig. 30, L) the arms of which extend to lateral, posterior margin; two setae borne between the posterior arm of the L-shaped marking and the clypeo-labral suture, one adjacent to anterior clypeal angle and one mesad and caudad of latter seta; *labral cleft* furnished on each side with a small seta; a long, strong seta on each anterior labral margin and one strong seta caudad and mesad of last mentioned seta.

Dorsal ocelli four in number, round to irregular ovate, arranged around the periphery of a small, round, sclerotized mound; *ventral ocelli* two in number, rounded, located on lateral margin of ventral surface of the head.

Antennae three-segmented with first two segments clavate and rather sparsely setose; second segment bearing a *sensory area* on the inner, anterior surface; third segment smaller, usually subulate; inner face of *antennal socket* furnished with a seta.

Maxillary palpiger closely connected with stipes; *mala* and *stipes* fused, stipes bearing two large setae anterior and one seta posterior to base of palpus; ventral surface of stipes furnished with one large seta caudad of palpus and adjacent to inner margin and one mesad of base of palpus; several small setae scattered over remainder of surface; *maxillary lobes* free distally, fused proximally; *maxillary palpus* three-segmented.

Galea with rounded, thickly-haired, brush-like tip which in *americana* extends posteriorly on inner, dorsal surface of stipes towards the base of palpus.

Lacinia (fig. 57, LC) furnished anteriorly with comb-like row of strong, broad spines; another similar row immediately dorsal to first with spines much shorter and arranged in a row like saw-teeth; lacinia furnished proximally with numerous very small spiculi.

Cardo irregularly sub-triangular, marked rather centrally by a Y-shaped suture with arms of Y directed towards posterior margin; anterior lateral margin furnished with two small setae.

Ligula bilobed.

Glossa with anterior margin thickly furnished with very short hairs, dorsal surface fleshy and furnished with numerous longitudinal rows of very fine, strong setae; lateral margin supported by a narrow, elongate sclerome.

*Hypopharyngeal sclerome*s symmetrical and well-defined; *bracon* and *rod* strong.

Mentum small; *submentum* trapezoidal with flaring base.

Gula small.

Labial palpus two-segmented, extending beyond glossa.

Epipharynx (fig. 30, EP) bilobed, with heavily sclerotized anterior and lateral margins furnished with rows of short, strong spines gradually

diminishing in size laterad; posterior region of the heavily sclerotized lateral margin furnished with a short, strong spine[2]; a short, rectangular spine[3] lies on each side of epipharyngeal cleft; caudad and slightly laterad of rectangular spine lies an oval area densely covered with slender spinules more or less parallel with anterior epipharyngeal margin; *first porous area* (fig. 30, IPA) is located between inner tips of the areas of slender spinules; caudad and laterad of first porous area lies *second porous area* (fig. 30, IIPA); caudad and laterad of these pores lies an elongate, oval area densely furnished with short, fine spiculi; about one-half the length from distal to proximal limits of the densely spined area and adjacent to the inner margins is located two quinque-porous areas (fig. 30, QPA); immediately anterior to last mentioned pores lies a flatly parabolic[4] row of minute pores extending from one lobe to the other; in line with this row on each side, but laterad, lies two minute setae, the first about two-thirds the length of parabolic row from the last pore, the second about one-half the length of parabolic row laterad of first.

Spiracles annular; opening kidney-shaped, wide, directed laterad and slightly caudad; *mesothoracic spiracle* about two times the size of other spiracles; *metathoracic spiracle* greatly reduced in size and probably non-functional; *abdominal spiracles* on first to eighth segments inclusive, borne ventrally near lateral anterior angle of dorsal shield.

Tergum rather sparsely setose; anterior lateral angle of *prothoracic shield* rounded, posterior lateral angle U-shaped; *mesothorax* similar to prothorax, but wider and only about seven-tenths as long; *metathorax* similar to other two, being about equal in width to mesothorax, but only about six-tenths as long as prothorax.

Dorsal shields (fig. 8) of abdomen sub-triangular, with anterior lateral angle rounded and furnished with two[5] strong setae accompanied by several smaller ones; posterior angle acute, directed laterad and slightly caudad; lateral margin furnished with several strong setae accompanied by smaller ones. Ten *abdominal segments* tapering from first to last, first five about equal in length, six to nine slightly longer; tenth segment trapezoidal, with strong setae on posterior half, with anus in which is located the *eversible anal processes* (fig. 3, AP); *tergum* and *sternum* furnished with numerous rather strong setae; posterior margin of the sternum of each segment with a row of long setae; *urogomphi* borne sub-dorsally between ninth and tenth abdominal segments.

Legs gradually increasing in length from first to third; furnished with numerous spine-like setae; *coxa* large, sub-pyriform, with deep longitudinal groove on outer face; *trochanter* small; *femur* about equal in length to coxa; *tibia* slightly shorter than femur; *tarsungulus* long, strong, with two small, lateral spines.

Sternal plate of prothorax orbicular, somewhat flattened anteriorly; *presternal sclerome* triangular, apex directed laterad, with a contiguous

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[2] *surinamensis* has four.

[3] Absent in *ramosa*.

[4] *lapponica* more acutely parabolic.

[5] *noveboracensis* has four to five.

plate lying laterad and caudad of it; *episternal sclerome* surrounding the anterior and lateral coxal margins; *epimeron* narrow, elongate, located adjacent to lateral coxal margin; *basisternum* soft, lighter in color and furnished with a small, central group of fine setae; *sternal plate* of first abdominal segment trapezoidal, accompanied on each side by a small rounded sclerite near lateral, sternal margin.

Ventral shields (fig. 2, VS) on abdominal segments two to eight inclusive similar to those of the dorsum; the lateral margins never extend beyond inner margin of spiracular *peritreme*; posterior margin furnished with a row of strong setae, surface sparsely setose.

SPECIFIC DESCRIPTIONS

Silpha americana L.

Twenty-five full-grown larvae; thirty immature larvae and numerous cast skins collected by the writer in College Park, Md., May 3 to September 1, 1939, around various carrion.

Egg when freshly laid ovoidal, chorion smooth and cream-colored with slight greenish tinge; about 3.12 mm. long and 2.27 mm. wide.

Length of *first instar larva* about 7.00 to 7.80 mm.; extreme width of metathorax about 3.00 to 3.80 mm. Length of *full-grown larva* about 24.00 to 25.00 mm.; extreme width of metathorax about 7.00 mm.; dorsum of mature larva black, sternum a grayish-black. Extreme width of *cranium* of first instar larva about 1.90 mm. Extreme width of *cranium* of mature larva about 3.10 mm.

Surface of *epicranium* reticulate; with a few very small setae. *Frons* more tuberculate, punctate, bearing several setae in each *anterior frontal angle* near antennal suture. *Frontal sutures* gradually concave anteriorly, extending posteriorly to a rounded, abrupt curve thence caudad to define a broadly U-shaped area; *posterior frontal angle* nearly 180°, located opposite the dorsal ocellar group; *epicranial* suture about two-fifths the length of the head. *Clypeus* with three setae on each half, one located near clypeo-labral suture near sagittal line of head, one located on lateral clypeal margin two-thirds the distance from posterior to anterior margin, and one located laterad and slightly caudad of first mentioned seta. *Labrum* with a wide carina on each side parallel with sloping lateral margin and one central carina perpendicular to clypeo-labral suture.

Antenna about as long as distance between inner, anterior region of bases of antennal sockets; first two segments about equal in length; *sensory area* consisting of irregular, oval, semi-transparent, plate-like spots; third segment most setose, tapering to a rather blunt apex, about four-fifths as long as other two segments, but only two-fifths as wide as anterior end of second. *Mandible* about as long as distance on epicranium between posterior, dorsal margin and base of antennal socket. Comb-like row of spines on *lacinia* consisting of twelve to thirteen hamate spines. *Maxillary palpus* sparsely setose; second segment clavate, broadest of the three; third segment subulate and the longest. Distal and proximal sclerites of *prementum* each bearing two strong setae

on each half and several small ones. *Labial palpus* with clavate first segment about twice the length of subulate second. *Second porous area* (fig. 30, IIPA) of *epipharynx* with each proximal pore provided with two openings. *Glossa* (fig. 12, GL) with rounded anterior margin; cleft about as deep as width of glossa (fig. 13, LCT).

Anterior inner margin of *prothoracic shield* furnished with a small, strong setae on each side; posterior margin of *dorsal shield* with four strong setae.

Urogomphus with first segment slightly concave along inner margin, about equal in length to tenth abdominal segment, with three strong setae on apical portion and numerous small setae on remainder of surface; second segment very small, bluntly subulate, only one-sixth as long as first, with two apical setae and several minute ones on remainder of surface.

Silpha inequalis Fab.

Thirty full-grown larvae, forty immature larvae, one pupa and numerous cast skins collected by the writer in College Park, Md., May 3 to September 1, 1939, around various carrion.

Egg when freshly laid sub-globular, chorion cream-colored with greenish tinge, pitted with numerous shallow indentations; about 1.59 mm. long and 1.31 mm. wide.

Length of *first instar larva* about 5.68 mm.; extreme width of *metathorax* about 2.69 mm. Length of *full-grown larva* about 16.61 mm.; extreme width of *metathorax* about 5.60 mm. Extreme width of *cranium* of first instar larva about 1.27 mm. Extreme width of *cranium* of mature larva about 2.03 mm.

Epicranium tuberculous, rather sparsely setose, with a row of setae immediately caudad of posterior region of frontal sutures. *Frontal suture, maxillary palpus* and *second porous area* of *epipharynx* similar to that of *americana*. *Frons* tuberculous with three strong setae in each *anterior frontal angle* and several smaller ones on remainder of surface. *Clypeus* with six strong setae on each side in anterior and lateral region accompanied by numerous smaller ones. *Labrum* similar to that of *americana*, but lacking the lateral carinae, being furnished instead with a small, rounded carina cephalad and slightly laterad of central carina on each half.

Antenna about as long as the distance between inner, anterior bases of antennal sockets; first and third segments about equal in length, second the longest; *sensory area* in form of a short, blunt cone about as high as width at base. *Mandible* about four-fifths as long as the distance on epicranium between posterior dorsal margin and the base of antennal socket. Comb-like row of spines on *lacinia* consisting of ten to eleven slightly hamate spines. *Distal sclerite* of prementum with two strong setae on each half and several smaller ones; *proximal sclerite* with three strong setae on each side and several smaller ones. *Labial palpus* with subulate second segment about two-fifths the length of clavate first. Glossa (fig. 15) with anterior margin rounded; cleft about one-half as deep as width of glossa.

Anterior inner margin of *prothoracic shield* furnished with two small, strong setae on each side.

Urogomphus about equal in length to tenth abdominal segment; first segment slightly concave along inner margin, with several small, strong setae on apical portion and numerous smaller ones on remainder of surface; second segment about three-tenths as long as first, bluntly subulate with two apical setae and several minute ones on remainder of surface.

Dorsal shield with one oblique marking (fig. 8) in anterior lateral region; posterior margin with five to seven strong setae.

Pupa similar to that of *noveboracensis*; pupal skin too badly mutilated after emergence of adult to permit accurate description.

Silpha noveboracensis Forst.

Thirty-five full-grown larvae, forty-five immature larvae, one pupa and numerous cast skins collected by the writer in College Park, Md., May 3 to September 1, 1939, around various carrion.

Egg when freshly laid sub-globular, chorion smooth, cream-colored with slight greenish tinge; about 1.76 mm. long and 1.31 mm. wide.

Length of *first instar larva* about 5.60 mm.; extreme width of *metathorax* about 2.70 mm. Length of *full-grown larva* about 14.50 mm.; extreme width of *metathorax* about 6.20 mm. Extreme width of *cranium* of first instar larva about 1.20 mm. Extreme width of *cranium* of mature larva about 2.00 mm.

The following parts as in *inequalis*: *Epicranium, frons, frontal sutures,* setation of *clypeus, labrum, antenna, mandible, maxillary* and *labial palpi, second porous area* of *epipharynx, sclerites* of *prementum*; anterior inner margin of *prothorax.*

Comb-like row of spines of *lacinia* consisting of ten slightly hamate spines. *Glossa* (fig. 18) with anterior margin rounded; cleft about as deep as width of glossa. *Dorsal shield* with two oblique, linear markings (fig. 7), one on dorsal and one on ventral surface; posterior margin with seven to eight strong setae.

Pupa exarate, slightly arcuate, cream-colored; extreme length about 13.20 mm.; extreme width of prothorax about 5.68 mm.

Abdomen gradually tapering; with nine segments, eight of them complete, but the sternum of the first missing; ninth segment small, furnished with two fleshy *cerci* each with a long, apical spine; two small annulated processes immediately ventral to *anus*; each lateral margin of abdominal segments two to seven inclusive, with a lateral process bearing a long, slender spine.

Spiracles on first eight abdominal segments. *Head* concealed when body is viewed dorsally; longer than wide; *vertex* rounded. *Epicranium* and *frons* furnished sparsely with small setae. *Labrum* deeply emarginate. *Pronotum* sub-trapezoidal with lateral margins well-rounded; posterior margin with a wide, even, central extension (fig. 55); anterior margin with two pairs of long, slender spines; posterior margin furnished

with a row of fine setae; remainder of pronotal surface thickly furnished with small setae, denser along margin. *Scutellum* of mesothorax large, triangular; scutellum of metathorax broadly triangular and partially obscured by that of mesothorax.

Silpha ramosa Say

One full-grown and one immature larva from vial marked "Tenino Wash., May 29, 1892, under stones in a meadow." Collector unknown.

Egg unknown. *First instar larva* unknown.

Length of *full-grown larva* about 20.50 mm.; extreme width of *metathorax* about 5.60 mm. Extreme width of *cranium* of mature larva about 2.40 mm. *Epicranium* and *frons* slightly punctate, reticulate and sparsely setose. Three strong setae borne in each *anterior frontal angle*; mesad of these is located a row of three strong setae on each side. *Frontal sutures* similar to those of *americana* except the *posterior frontal* angle which is slightly less than 180°. *Clypeus* with a row of five strong setae on each side adjacent to anterior margin; one smaller seta on each lateral margin and numerous small setae on remainder of surface. *Labrum* as in *inequalis* except that the arms of the lateral L-shaped marking are much wider. *Antenna* slightly longer than extreme width of cranium; second segment shortest and third segment longest of the three; *sensory area* as in *americana*; segments furnished with very fine setae; those of the second segment slightly stronger. *Length of mandible* about one-half the extreme width of head. Comb-like row of spines on *lacinia* consisting of eleven to twelve subulate spines. *Maxillary* palpus similar to that of *americana*. *Sclerites* of *prementum* with arrangement of setae as in *americana*. *Labial palpus* as in *americana* except that second segment is about three-fifths the length of the first. *Second porous area* of *epipharynx* consisting of one bi-porous area on each side. Central *rectangular spines* on anterior epipharyngeal margin lacking. *Glossa* (fig. 21) flattened anteriorly; with rounded, inner anterior angle, outer anterior angle more acute; cleft not quite as deep as width of glossa.

Anterior inner margin of *prothoracic shield* furnished with one small, strong seta and numerous smaller ones on each side; posterior margin of *dorsal shield* with four strong setae.

Urogomphus with single segment furnished with one strong apical seta and numerous smaller ones on remainder of surface; shorter than tenth abdominal segment.

Pupa unknown.

Silpha lapponica Hbst.

One full-grown larva from vial marked "San Jose, Calif."; collector, host and date of collection unknown.

Egg unknown. *First instar larva* unknown.

Length of *full-grown larva* about 17.00 mm.; extreme width of *metathorax* about 4.60 mm. Extreme width of *cranium* of mature larva about 2.20 mm.

Epicranium reticulate, slightly tuberculate, sparsely setose. *Frons* reticulate and sparsely setose; furnished with three strong setae in each *anterior frontal angle*. *Frontal sutures* similar to those of *americana*, but more narrowly U-shaped. *Clypeus* with two strong setae on each half near anterior margin; one seta on each lateral margin; remainder of surface sparsely furnished with small setae. *Labrum* as in *inequalis*.

Antenna about as long as width of posterior margin of clypeus; first and third segments about equal in length; second segment longest of the three; sensory area as in *inequalis*; segments sparsely setose. *Mandible* slightly shorter than width of proximal margin of labrum. Comb-like row of spines on *lacinia* consisting of ten slightly hamate spines. *Maxillary palpus* similar to that of *americana*. Arrangement of *setae* on sclerites of *prementum* as in *americana*. *Labial palpus* similar to that of *americana*. *Second porous area* of *epipharynx* consisting of a tri-porous area on each side. *Glossa* (fig. 24) with flattened anterior margin, anterior angles well rounded; cleft slightly deeper than width of glossa.

Anterior inner margin of *prothoracic shield* furnished with two setae, one strong, one smaller, on each side; posterior margin of *dorsal shield* furnished with two strong setae.

Tenth abdominal segment about three-fifths the length of first segment of *urogomphus*; second segment of *urogomphus* small; both segments sparsely furnished with small, strong setae.

Pupa unknown.

Silpha surinamensis Fab.

Four full-grown larvae and one immature larva from vial marked "Michipecoten Island, L. Sc., July, 1876, in fish offal"; collector unknown.

Egg unknown. *First instar larva* unknown.

Length of *full-grown larva* about 26.00 mm.; extreme width of *metathorax* about 6.10 mm. Extreme width of *cranium* of mature larva about 2.70 mm.

Epicranium tuberculate, sparsely furnished with scattered setae. *Frons* tuberculate, very sparsely setose; two strong setae borne in each *anterior frontal angle*. *Frontal sutures* similar to those of *americana*. *Clypeus* short and broad, furnished with setae as in *lapponica*, but with two additional setae located rather centrally on anterior margin. *Labrum* somewhat similar to that of *inequalis*, but directed rather sharply ventrad. *Carinae* not prominent.

Antenna slightly longer than width of anterior margin of clypeus; first segment longest and widest of the three; second segment slightly longer than third; third subulate and less than one-half as wide as apex of second; *sensory area* a minute, very blunt cone; all three segments sparsely setose.

Mandible about as long as combined length of first and second antennal segments. Comb-like row of spines on *lacinia* consisting of nine spines. *Maxillary palpus* with segments about equal in length and sparsely setose; third subulate and much narrower than other two.

Sclerites of *prementum* with arrangement of setae as in *americana*. *Labial palpus* with first segment clavate; second segment subulate and only two-fifths as long as first; both segments without setae. *Second porous area* (fig. 34) of epipharynx consisting of three pores on each side. *Glossa* (fig. 27) with rounded anterior margin; cleft about one-third as deep as width of glossa. Anterior inner margin of *prothoracic shield* without prominent setae; posterior margin of *dorsal shield* with four to five strong setae.

Tenth abdominal segment about two-fifths as long as first segment of *urogomphus*; second segment of urogomphus about one-sixth the length of the first; first segment furnished with small, strong setae, the bluntly subulate second segment very sparsely setose.

Pupa unknown.

KEY SEPARATING THE LARVAE OF SILPHA

1. Urogomphus with one segment.
   Third antennal segment longer than second; sensory area on second antennal segment in form of plate-like spots (p. 129)..... **ramosa**
2. Urogomphus with two segments.
   A. Urogomphus longer than tenth abdominal segment.....(1)
      (1) Urogomphus more than twice the length of tenth abdominal segment; first segment of labial palpus at least three times the length of second; labrum directed sharply ventrad (p. 130)..... **surinamensis**
      (2). Urogomphus not twice the length of tenth abdominal segment; first segment of labial palpus not three times length of second.....(a)
         (a). Ligular lobes rounded anteriorly; sensory area on second antennal segment plate-like; usually black in color (p. 126), **americana**
         (b). Ligular lobes more flattened anteriorly; sensory area on second antennal segment a very small, blunt cone (p. 129).... **lapponica**
   A.A. Urogomphus not longer than tenth abdominal segment.....(1)
      (1). Sensory area on second antennal segment bluntly conical in form and definitely extending erect from the surface at least as high as width at base; third segment of maxillary palpus slightly longer than second; dorsal shields not overlapping; shields with one oblique marking in anterior, distal portion; terga not marked with prominent dark spots (p. 127)..... **inequalis**
      (2). Dorsal shields closer together and often overlapping; shields with two oblique, linear markings; terga marked with evenly arranged, prominent, dark spots; otherwise same as (1) A.A. (p. 128), **noveboracensis**

SUMMARY

The foregoing study has revealed a number of rather distinctive generic characteristics as well as characters which are definitive for each species. The external anatomy of the larvae of the genus *Silpha*, generally speaking, is similar. The variation in the structure of certain anatomical parts is obvious enough, in most cases, to permit of rather easy separation of the species. The characters of the internal and external mouthparts and the tenth abdominal segment together with the accompanying appendages of the ninth proved to be most useful for

taxonomic purposes. The structure of the epi- and hypopharyngeal regions suggests that the careful study of corresponding regions in other Staphylinoidea might prove to be helpful in future taxonomic investigations among those larvae.

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EXPLANATION OF PLATES[6]

PLATE I

Fig. 1, *Silpha americana* L. Dorsal view. 2, *Silpha americana* L. Ventral view. 3, *Silpha noveboracensis* Forst. Ninth and tenth abdominal segments, ventral view. Anal processes everted. 4, *Silpha surinamensis* Fab. Ninth and tenth abdominal segments, dorsal view. 5, *Silpha ramosa* Say. Ninth and tenth abdominal segments, dorsal view. 6, *Silpha lapponica* Hbst. Ninth and tenth abdominal segments, dorsal view. 7, *Silpha noveboracensis* Forst. Dorsal shield, dorsal view. 8, *Silpha inequalis* Fab. Dorsal shield, dorsal view. 9, *Silpha americana* L. Ninth and tenth abdominal segments, dorsal view. 10, *Silpha noveboracensis* Forst. Ninth and tenth abdominal segments, dorsal view. 11, *Silpha inequalis* Fab. Ninth and tenth abdominal segments, dorsal view.

PLATE II

Fig. 12, *Silpha americana* L. Labium, dorsal view. 13, *Silpha americana* L. Labium, ventral view. 14, *Silpha americana* L. Labium, lateral view. 15, *Silpha inequalis* Fab. Labium, dorsal view. 16, *Silpha inequalis* Fab. Labium, ventral view. 17, *Silpha inequalis* Fab. Labium, lateral view. 18, *Silpha noveboracensis* Forst. Labium, dorsal view. 19, *Silpha noveboracensis* Forst. Labium, ventral view. 20, *Silpha noveboracensis* Forst. Labium, lateral view. 21, *Silpha ramosa* Say. Labium, dorsal view. 22, *Silpha ramosa* Say. Labium, lateral view. 23. *Silpha ramosa* Say. Labium, ventral view.

PLATE III

Fig. 24, *Silpha lapponica* Hbst. Labium, dorsal view. 25, *Silpha lapponica* Hbst. Labium, ventral view. 26, *Silpha lapponica* Hbst. Labium, lateral view. 27, *Silpha surinamensis* Fab. Labium, dorsal view. 28, *Silpha surinamensis* Fab. Labium, ventral view. 29, *Silpha surinamensis* Fab. Labium, lateral view. 30, *Silpha americana* L. Labrum, ventral view showing epipharynx. 31, *Silpha inequalis* Fab. Labrum, ventral view showing epipharynx. 32, *Silpha lapponica* Hbst. Labrum, ventral view showing epipharynx. 33, *Silpha ramosa* Say. Labrum, ventral view showing epipharynx. 34, *Silpha surinamensis* Fab. Labrum, ventral view showing epipharynx. 35, *Silpha noveboracensis* Forst. Labrum, ventral view showing epipharynx. 36, *Silpha inequalis* Fab. Mandible, ventral view. 37, *Silpha ramosa* Say. Mandible, ventral view.

PLATE IV

Fig. 38, *Silpha americana* L. Mandible, dorsal view. 39. *Silpha americana* L. Mandible, ventral view. 40, *Silpha surinamensis* Fab. Mandible, ventral view. 41, *Silpha lapponica* Hbst. Mandible, ventral view. 42, *Silpha noveboracensis* Forst. Mandible, ventral view. 43, *Silpha americana* L. Head, dorsal view. 44, *Silpha americana* L. Head, ventral view. 45, *Silpha noveboracensis* Forst. Head, dorsal view. 46, *Silpha noveboracensis* Forst. Head, ventral view. 47, *Silpha inequalis* Fab. Head, ventral view. 48, *Silpha inequalis* Fab. Head, dorsal view. 49, *Silpha lapponica* Hbst. Head, dorsal view. 50, *Silpha lapponica* Hbst. Head, ventral view.

PLATE V

Fig. 51, *Silpha ramosa* Say. Head, dorsal view. 52, *Silpha ramosa* Say. Head, ventral view. 53, *Silpha surinamensis* Fab. Head, dorsal view. 54, *Silpha surinamensis* Fab. Head, ventral view. 55, *Silpha noveboracensis* Forst. Pupa, dorsal view. 56, *Silpha noveboracensis* Forst. Pupa, ventral view. 57, *Silpha americana* L. Maxilla, ventral view. 58, *Silpha americana* L. Metathoracic leg viewed from the front.

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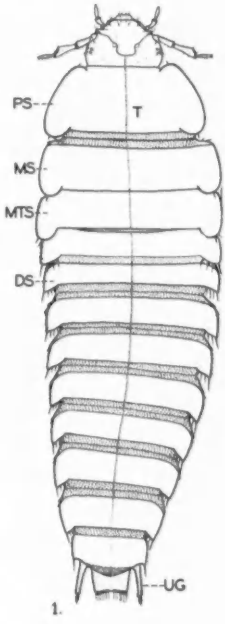
[6]All drawings were made by the writer.

ABBREVIATIONS USED ON THE FIGURES

A, anus.
AFA, anterior frontal angle.
ANP, annulated process.
ANT, antenna.
AP, anal process.
AS, antennal socket.
B, base of mandible.
C, cercus.
CD, cardo.
CFS, clypeo-frontal suture.
CLP, clypeus.
CLS, clypeo-labral suture.
CX, coxa.
DOC, dorsal ocelli.
DS, dorsal shield.
DT, dorsal spots of distal tentorial arms.
EP, epipharynx.
EPC, epipharyngeal cleft.
EPM, epimeron.
ES, epicranial suture.
ESTSC, episternal sclerome.
FEM, femur.
FR, front.
FS, frontal suture.
GA, galea.
GL, glossa.
GU, gula.
HB, hypopharyngeal bracon.
HPHY, hypopharynx
HPHYS, hypopharyngeal sclerome.
HR, hypopharyngeal rod.
INL, incisor lobe of mandible.
LB, labium.
LBPLP, labial palp.
LC, lacinia.
LCT, ligular cleft.
LEG, leg.
LIG, ligula.
LM, labrum.
MD, mandible.
MS, mesothoracic shield.
MT, mentum.
MTS, metathoracic shield.
MXPLP, maxillary palp.
IPA, first porous area of epipharynx.
IIPA, second porous area of epipharynx.
PFA, posterior frontal angle.
PLP, palp.
PMT, postmentum.
PNT, pronotum.
POC, postocciput.
POS, postoccipital suture.
PRMT, prementum.
IPRMT, anterior subdivision of prementum.
IIPRMT, posterior subdivision of prementum.
PS, prothoracic shield.
PSCL, presternal sclerome.
PSTPL, sternal plate of prothorax.
PT, tentorial pits.
QPA, quinque-porous area of epipharynx.
RS, rectangular spine.
SA, sensory area.
SCT, scutellum.
SP, spiracle.
ST, stipes.
T, tergum.
TAR, tarsungulus.
TIB, tibia.
TR, trochanter.
UG, urogomphus.
VOC, ventral ocelli.
VS, ventral shield.
W, wing.



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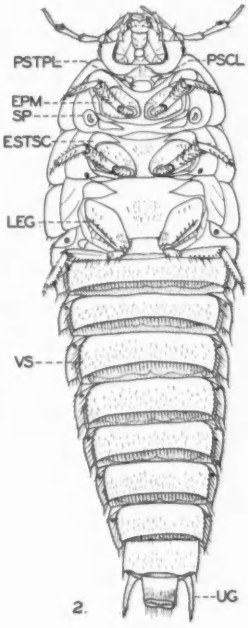

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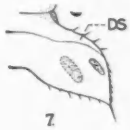

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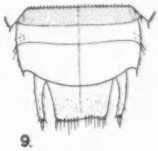

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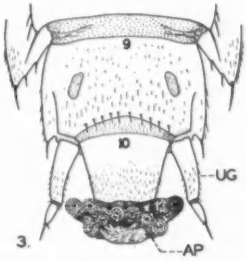

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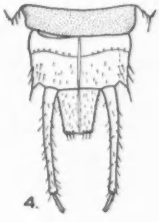

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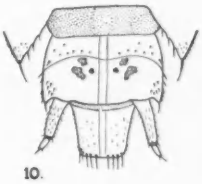

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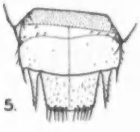

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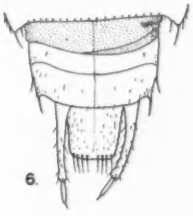

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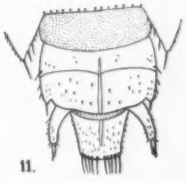

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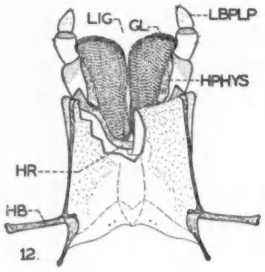

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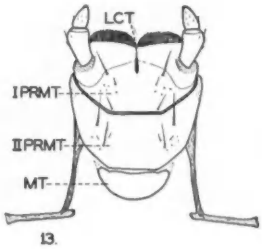

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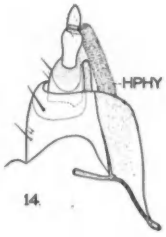

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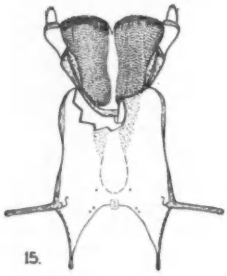
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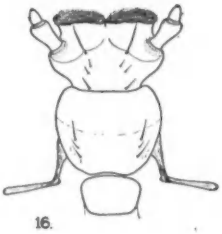
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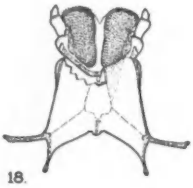
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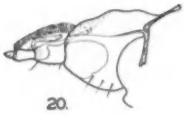
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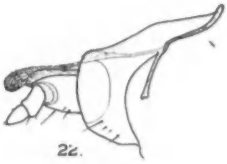
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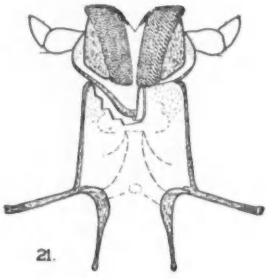
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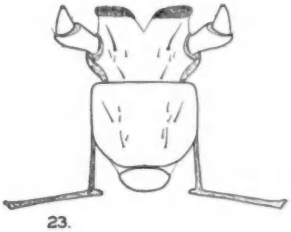
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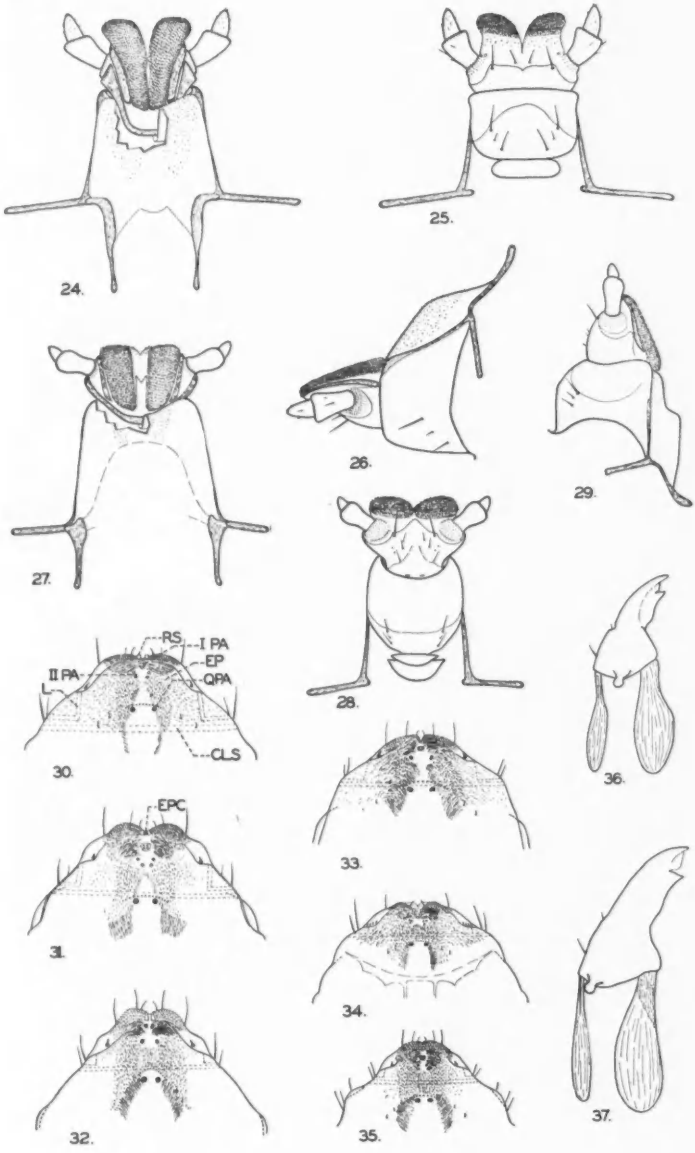
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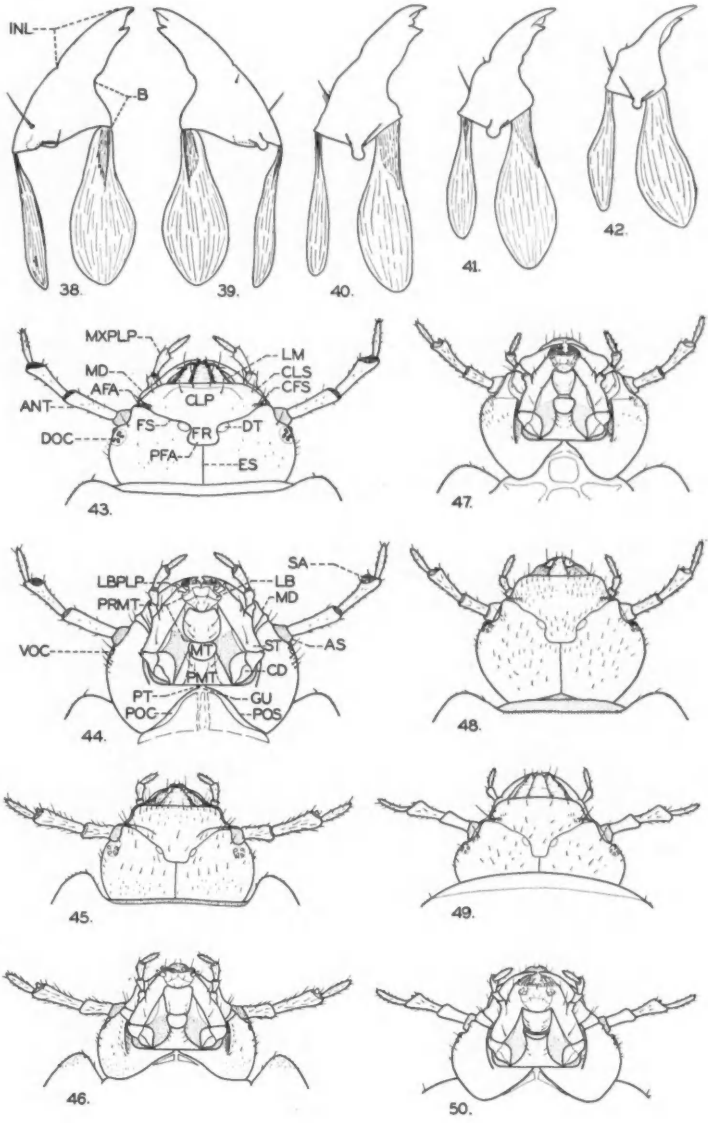
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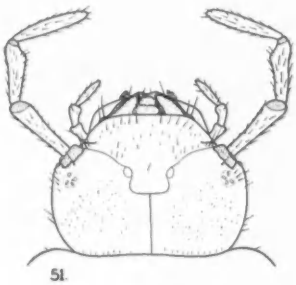

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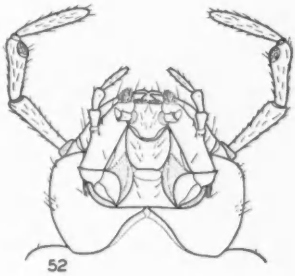

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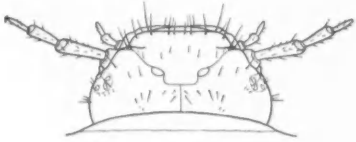

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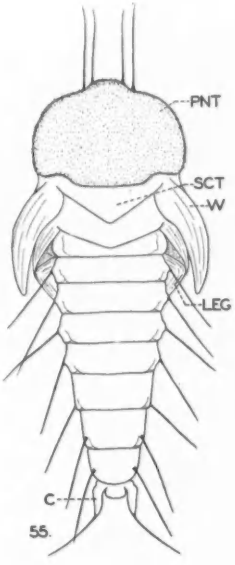

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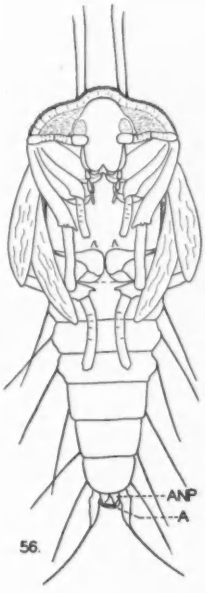

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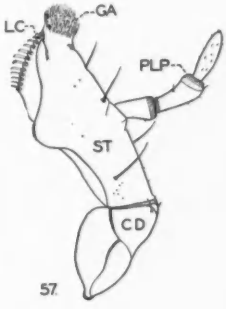

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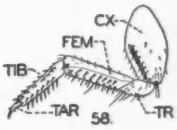

58.

STUDIES ON THE CRANE-FLIES OF MEXICO

PART VII[1]

(Order Diptera, Superfamily Tipuloidea)

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In this paper I wish to discuss species of Tipulidae that were taken by Dr. Alfons M. Dampf in the State of Chiapas, as discussed in some detail in an earlier part under this general title (Annals Ent. Soc. America, 31: 393; 1938). A smaller number of species were secured by Mr. Harry Hoogstraal in Nuevo Leon and by Mr. A. E. Pritchard in Guerrero. I am greatly indebted to Messrs. Dampf, Hoogstraal and Pritchard for the privilege of retaining the types of the novelties in my private collection of these flies.

Ozodicera Westwood

Ozodicera (Ozodicera) septemtrionis sp. n.

General coloration of mesonotum brownish gray, the praescutum with four more reddish brown stripes that are narrowly bordered by slightly darker brown; pleura buffy yellow; wings with a brown tinge, the costal border and stigma darker; *Rs* longer than R_{2+3}; abdominal tergites brownish yellow with blackened lateral stripes; male hypopygium with the basistyle produced at apex into a strong blackened spine; gonapophyses conspicuously blackened, the inner appearing as flattened blades, the outer as slender spines.

Male.—Length about 24 mm.; wing, 18 mm.; antenna about 6 mm.

Frontal prolongation of head relatively long, yellowish brown; nasus distinct; palpi brownish black. Antennae of moderate length; scape and pedicel yellow, flagellum brown, the branches a little darker; simple apical segments about equal in total length to the basal seven flagellar segments combined; branches of flagellar segments two to seven a trifle shorter than the segments. Head light brown; anterior vertex relatively narrow, a little less than the diameter of scape.

Mesonotal praescutum brownish gray with four more reddish brown stripes that are narrowly bordered by slightly darker brown; scutum with median area darker brown than the lobes, the latter sparsely variegated with yellow; scutellum a little darker brown than the parascutella; mediotergite buffy yellow, slightly darker brown on either side of median line. Pleura buffy yellow. Halteres with stem brownish

[1]The preceding part under this general title appeared in these Annals (Vol. XXXII, 70–90, 1939). Contribution from the Entomological Laboratory, Massachusetts State College.

yellow, knob slightly darker. Legs with coxae and trochanters yellow; femora and tibiae brownish yellow, the tips narrowly dark brown; tarsi passing into black. Wings with a brownish tinge, the prearcular field and cells *C* and *Sc* more saturated; stigma brown; veins brown. Venation: *Rs* relatively long, arcuated, exceeding R_{2+3}; distal half of vein R_{1+2} pale but evident; cell *1st* M_2 large; cell *2nd A* relatively wide.

Abdominal tergites yellow, more brownish yellow beyond the base, the lateral borders conspicuously blackened to form conspicuous stripes; terminal segments more uniformly blackened; sternites obscure yellow. Male hypopygium with apex of basistyle produced into a strong blackened spine, the tip acute. Outer dististyle with apex shallowly and unequally bidentate, the outer margin near base with a short lobe. Inner dististyle subequal in length, appearing as a strongly flattened pale blade. Inner gonapophyses appearing as flattened black blades, the tips extended into acute spines; outer gonapophyses appearing as slender acute spines.

HABITAT: Mexico (Chiapas). *Holotype*, ♂, Finca San Cristobal, June 19, 1935 (A. M. Dampf); M. F. 4560.

Ozodicera (*Ozodicera*) *septemtrionis* is the most northern member of the genus so far discovered. It is allied to *O.* (*O.*) *panamensis* Alexander, differing most evidently in the very different construction of the male hypopygium, notably the spinous tips of the basistyles.

Tipula Linnaeus

Tipula (Bellardina) parrai sp. n.

Mesonotal praescutum greenish yellow, with four scarcely differentiated stripes that are narrowly bordered by darker; antennal flagellum bicolored; scape very long, pale yellow; femora with pale subterminal ring; wings conspicuously variegated brown, yellow and subhyaline; radial veins beyond cord with conspicuous trichia; *Rs* short, about two-thirds *m-cu*; R_{4+5} strongly sinuous; male hypopygium large; caudal margin of the tumid ninth tergite notched; ninth sternite with a conspicuous ligulate median lobe.

Male.—Length about 22 mm.; wing, 24 mm.; antenna about 5 mm.

Frontal prolongation of head relatively long, yellowish brown; nasus stout, truncated at apex; palpi dark brown, the incisures somewhat paler. Antennae with scape and pedicel yellow; flagellum bicolored, the segments dark brown at bases, the remainder pale yellow; scape unusually long, nearly equal to the combined basal three flagellar segments; basal enlargements of segments feebly developed; verticils longer than the segments; terminal segment narrowed at apex, the latter subequal in length to the basal enlargement. Head greenish yellow; vertical tubercle low.

Pronotum high, obscure yellow, with a narrow brown median line. Mesonotal praescutum greenish yellow, the four stripes scarcely differentiated in color, best indicated by narrow margins, the mesal edges of

the intermediate stripes more reddish brown, confluent to form a median vitta; borders of lateral stripes darker brown, especially in front; scutum pale, each lobe with two concolorous pale areas that are encircled by light brown; scutellum and mediotergite pale yellow, sparsely pruinose. Pleura yellow, weakly patterned with brown, including the propleura and anepisternum; dark lines on dorsal sternopleurite and ventral meron. Halteres yellow. Legs with the coxae brownish yellow, restrictedly darkened by lines, basal on the fore and hind coxae, apical on the mid-coxae; trochanters yellow; femora yellow basally, passing into brownish yellow, the distal fourth dark brown, enclosing a narrow, pale yellow, subterminal ring; tibiae brownish yellow, the tips scarcely darkened; tarsi black, the proximal half of basitarsi pale; claws (male) with basal tooth. Wings pale brown, variegated by whitish subhyaline, pale yellow and darker brown areas; cells *C* and *Sc* almost uniformly pale yellow; the white colors appear as a narrow subtransverse fascia before cord, extending from *R* to posterior margin; outer ends of all marginal cells with white markings, subtended by darker brown spots at ends of veins, most distinct in the outer medial field; other pale spots in vicinity of cord and in basal portions of cells *Cu*, *1st A* and *2nd A*; bases of cells *R* and *M* extensively yellow; veins yellow, narrowly bordered on membrane by the same color. Macrotrichia on veins beyond cord, including basal half of R_3, all of distal section of R_{4+5} excepting the base; restricted trichia on veins M_1 and M_2; squama with a few coarse setae. Venation: R_3 nearly straight but R_{4+5} strongly sinuous, cell R_5 conspicuously narrowed on basal fourth; *Rs* short and unusually straight, about two-thirds as long as *m-cu*; *m-cu* on M_4 just beyond origin of latter.

Abdominal tergites brownish yellow, restrictedly darkened sublaterally, the margins narrowly gray; sternites and hypopygium more reddish brown. Male hypopygium large and conspicuous. Tergite tumid, the caudal margin with a broad U-shaped notch. Ninth sternite with a conspicuous ligulate median lobe, slightly narrowed outwardly, with a weak median incision; surface of lobe with delicate pale pubescence.

HABITAT: Mexico (Chiapas). *Holotype*, ♂, Porvenir, altitude 2,500 meters, May 10, 1935 (J. Parra); Dampf M. F. 4131.

This distinct fly is named in honor of the collector, Inspector Josè Parra. It is quite different from *Tipula* (*Bellardina*) *craverii* Bellardi, which it most resembles. The presence of numerous trichia on the veins beyond the cord of the wing is in disagreement with the subgeneric characters but the fly seems to be correctly placed in *Bellardina* Edwards.

Tipula (Bellardina) schizomera sp. n.

Belongs to the *oblique-fasciata* group; femora virtually without pale rings; wings with outer medial field narrowly bordered by dark brown, each cell there variegated by a pale triangular spot; male hypopygium relatively small; outer dististyle split; ninth sternite produced medially.

Male.—Length about 23 mm.; wing, 22 mm.; antenna about 4 mm. Frontal prolongation of head light brown; nasus conspicuous; palpi dark brown, the intermediate two segments paler. Antennae relatively short, obscure yellow, the basal enlargements of the outer segments darker; verticils very long and conspicuous, exceeding twice the length of the segments. Head gray, the genae and a median vitta on vertex brown; vertical tubercle simple.

Mesonotal praescutum with the ground reddish brown, with four grayish stripes that are narrowly bordered by darker brown; posterior sclerites of notum light brown, variegated by paler, more yellow areas. A conspicuous dorsal whitish longitudinal stripe, involving the sides of the pronotum, dorsopleural region, lateral pretergites and a post-humeral area on praescutum, extending to the wing-root, the stripe clearly delimited below by a dark brown longitudinal stripe extending from the cervical region across the propleura and anepisternum; sternopleurite, meron and tubercle of pleurotergite with a dense white bloom, the extreme ventral sternopleurite again darkened; posterior sclerites of pleura, except as above described, brown to brownish yellow. Halteres obscure yellow, the knobs dark brown. Legs with the coxae whitish pollinose; trochanters obscure yellow; femora brown, paler basally, on all legs with the vaguest possible indication of a pale ring before the dark brown tips; tibiae obscure yellow, the tips weakly darkened; tarsi brown, passing into dark brown. Wings with the ground color light brown, variegated by grayish brown, dark brown and whitish subhyaline areas; prearcular and costal fields somewhat uniformly darkened; a pale band extending obliquely basad from *C* to *M*, its outer edge at origin of *Rs*; outer medial cells more grayish, narrowly bordered along margin by dark brown, the center of each cell in this marginal band with a white triangular spot; remainder of disk, especially beyond stigma, cell R_5, Cubital and anal cells variegated by pale; veins chiefly light yellow. Veins beyond cord, especially in radial field, with sparse trichia. Venation: *Rs* short, subequal to *m-cu*; cell R_3 slightly constricted before midlength; *m-cu* a short distance before form of M_{3+4}.

Abdominal tergites obscure brownish yellow, with a scarcely evident, more reddish brown, median stripe and narrow blackish sublateral stripes, the extreme borders of the tergites brownish gray; sternites yellowish brown, variegated by more yellowish areas; hypopygium concolorous. Male hypopygium relatively small. Tergite extensive, the caudal margin transverse or very gently emarginate medially, the caudal-lateral angles produced into low triangular ears. Outer dististyle narrow, on outer margin at near two-thirds the length bearing a curved horn-like branch, beyond this point the style narrowed, its apex truncate. Ninth sternite produced caudad into a depressed median lobe, the apex truncate.

HABITAT: Mexico (Chiapas). *Holotype*, ♂, San Cristobal, June 8, 1926 (A. M. Dampf); M. F. 952. *Paratopotype*, ♂.

Tipula (*Bellardina*) *schizomera* is allied to *T.* (*B.*) *craverii* Bellardi and *T.* (*B.*) *parrai* sp. n., differing in the details of coloration of the body and wings and in the structure of the

male hypopygium. The conditions existing in the vicinity of San Cristobal las Casas, where the types of the present fly were taken, have been discussed in an earlier paper under this general series (Annals Ent. Soc. America, 20: 301–302; 1927).

Tipula (Lunatipula) hoogstraali sp. n.

Belongs to the *triplex* (*umbrosa*) group; general coloration gray, the praescutum with four conspicuous dark brown stripes; nasus reduced or lacking; wings of male normal, strongly suffused with brownish gray, variegated with darker brown; a very conspicuous obliterative area before cord; wings of female semiatrophied, strongly pointed beyond cord; abdomen reddish orange, the tergites narrowly trivittate with blackish, the median stripe becoming obsolete on outer segments; male hypopygium with spines of eighth sternite slender, widely separated.

Male.—Length about 19–20 mm.; wing, 22–24 mm.; antenna about 7 mm.

Female.—Length about 27 mm.; wing, 16 mm.

Male.—Frontal prolongation of head gray; nasus lacking or reduced to a blunt tubercle; palpi black. Antennae with scape and pedicel obscure yellow, flagellum brownish black; flagellar segments moderately incised; longest verticils a little shorter than the segments. Head gray, with a conspicuous brown median line; vertical tubercle low.

Pronotum gray, narrowly darkened medially. Mesonotal praescutum yellowish gray, with four conspicuous, entire, dark brown stripes, the intermediate pair subobsolete on anterior third; posterior sclerites of notum clearer gray, the scutal lobes with two more brownish gray areas; scutellum in cases slightly tinged with brown. Pleura light gray, the ventral sternopleurite and meron darker gray; dorsopleural membrane yellow. Halteres with stem yellow, knob dark brown. Legs with the coxae light gray; trochanters reddish brown; femora reddish brown, the tips blackened; tibiae reddish brown, the tips narrowly blackened; basal segments of tarsi light brown, the outer segments blackened. Wings with the ground color brownish gray; stigma dark brown; origin of *Rs*, cord and cell Cu_1 narrowly seamed with paler brown; a very conspicuous whitish obliterative area from before stigma into the base of cell M_3, lying before level of cord; veins brown. Venation: Outer end of cell *1st* M_2 pointed.

Abdominal tergites light reddish orange, narrowly trivittate with blackish, the sublateral stripes more nearly continuous, the median stripe becoming obsolete or nearly so on outer segments; lateral tergal margins buffy; sternites reddish yellow; outer segments, including hypopygium, more uniformly darkened. Male hypopygium of the *triplex* type; submedian teeth of tergite moderately slender, separated by a linear notch. Spines of eighth sternite slender, widely separated.

Female.—Generally as in male, differing in the sexual characters. Legs stouter. Wings tending to become atrophied, as shown by the measurements; beyond cord, wing strongly pointed, the venation slightly distorted. Ovipositor with slender cerci.

HABITAT: Mexico (Nuevo Leon). *Holotype*, ♂, Cerro Potosi, altitude 11,800 feet, July 13, 1938 (H. Hoogstraal). *Allotopotype*, ♀, with the type, resting on pine. *Paratopotypes*, 1 ♂, altitude 7,000 feet, June 25, 1938; 5 ♂♂, altitude 12,000–12,300 feet, July 12–August 3, 1938.

I take great pleasure in naming this species in honor of the collector, Mr. Harry Hoogstraal. Although closely allied to other members of the group, including the eastern Nearctic *Tipula* (*Lunatipula*) *flavoumbrosa* Alexander, *T.* (*L.*) *perlongipes* Johnson, *T.* (*L.*) *triplex* Walker, and *T.* (*L.*) *umbrosa* Loew, the present species is quite distinct in the gray coloration of the body and in the patterned wings which are semiatrophied in the female.

Tipula (Microtipula) obscuricincta sp. n.

Mesonotal praescutum yellow pollinose, with four entire brown stripes; femora obscure brownish yellow with an obscure yellow subterminal ring; wings pale yellow, patterned with brown, most intense in the costal field; yellow crossband before cord complete, involving outer ends of cells *Cu* and *1st A*; vein R_{2+3} relatively long, about two-thirds *Rs*; cell *1st* M_2 short-pentagonal.

Male.—Length about 7 mm.; wing, 8.5 mm.; antenna about 3 mm.

Female.—Length about 8.5 mm.; wing, 9.2 mm.

Frontal prolongation of head yellow above, darker on sides; nasus lacking; palpi black. Antennae 13-segmented; scape and pedicel pale yellow; flagellar segments one to seven bicolored, black basally, the tip yellow, the latter color most extensive on the proximal segments where about the distal third is included, decreasing on the outer segments; terminal segments uniformly pale brown; verticils shorter than the segments; terminal segment more than one-third the length of the penultimate. Front pale yellow, the vertex infuscated.

Pronotum yellowish brown. Mesonotal praescutum with the ground color yellow pollinose, with four entire brown stripes; intermediate pair very narrowly separated by a pale vitta, confluent behind; in holotype male, the anterior half of intermediate stripes much paler than the remainder; scutal lobes entirely dark brown, restrictedly paler on midline; scutellum obscure yellow, parascutella dark; postnotum dark brown. Pleura obscure yellow, including the dorsopleural membrane; dark brown areas on anepisternum, sternopleurite and meron. Halteres yellow, knobs dark brown. Legs with the coxae testaceous yellow; trochanters yellow; femora obscure brownish yellow, with an obscure yellow subterminal ring that is placed about its own length before the blackened tip; tibiae and tarsi black. Wings with the ground color pale yellow, heavily patterned with brown, appearing chiefly as four irregular crossbands that are much deeper in color in the costal field; cells beyond cord variegated by pale, including a broad post-stigmal crossband and spots in the outer medial field; yellow band before cord complete,

involving the outer ends of cells *Cu* and *1st A*, not interrupted in cell *R*, as in *costaricensis*; cell *1st A* with an extensive pale area on basal third; veins dark, paler in the ground areas. Venation: R_{2+3} relatively long, about two-thirds *Rs*; cell *1st* M_2 short-pentagonal; M_{3+4} short, subequal to *m*; cell M_1 deep, exceeding twice its petiole (in female) or even deeper (male), with the petiole subequal to *m*; cell *2nd A* wider than in *costaricensis*.

Abdomen almost uniformly dark brown, the caudal-lateral portions of the tergites a little more grayish. Ovipositor with the genital shield yellow; cerci straight to slightly decurved; hypovalvae short.

HABITAT: Mexico (Chiapas). *Holotype*, ♀, Finca Vergel, altitude 800 meters, at light, 6 P. M. to 6 A. M., May 11, 1935 (A. M. Dampf); M. F. 4123. *Allotopotype*, ♂, May 15, 1935; M. F. 4185.

Tipula (*Microtipula*) *obscuricincta* is closest to *T.* (*M.*) *costaricensis* Alexander, which was hitherto the most northerly representative of the subgenus. The latter differs most conspicuously in the coloration of the praescutum, femora and wings, and in the details of venation.

Tipula temperata sp. n.

General coloration of mesonotal praescutum and scutum uniformly orange, scutellum and mediotergite more testaceous yellow; setae of praescutum very reduced; antennae (male) elongate, exceeding one-half the length of body, bicolored; legs yellow, the tarsi passing into brownish black; wings yellow, the cells beyond cord whitish hyaline; a heavy brown pattern, including the costal border and wing apex, with seams on the cord and on veins beyond it; abdomen reddish yellow, with a black subterminal ring; male hypopygium with caudal margin of tergite nearly transverse to very shallowly emarginate, each side with a continuous series of short black spines.

Male.—Length about 12 mm.; wing, 12 mm.; antenna about 6.5 mm.

Frontal prolongation of head reddish brown; nasus distinct; palpi yellowish brown. Antennae (male) long, exceeding one-half the length of body; scape and pedicel yellow; flagellum bicolored, yellow, the flagellar segments from the third to tenth, inclusive, with the basal enlargement brownish black, the remainder yellow; basal two flagellar segments yellow; terminal segment uniform brownish black; flagellar segments moderately incised; longest verticils a little shorter than the segments. Head fulvous, the anterior vertex with a delicate brown median vitta; vertical tubercle low.

Mesonotal praescutum and scutum uniformly orange, without markings; setae of praescutal interspaces very reduced in size; scutellum and mediotergite testaceous yellow, the pleurotergite a little darker. Pleura uniformly yellow. Halteres yellow, the knobs weakly darkened. Legs with the coxae and trochanters yellow; femora and tibiae uniformly yellow; tarsi passing into brownish black. Wings with the cells before

cord weakly suffused with yellow, at and beyond cord whitish hyaline; a heavy brown pattern, as follows: Prearcular region; cells *C* and *Sc*, the latter area involving also the anterior portion of cell *R*, paling behind; wing tip from stigma to end of vein *Cu*, most extensive in outer radial field, narrowest in outer medial field; broad seams on *m-cu* and outer section of Cu_1, narrower on anterior cord, base of vein R_{4+5}, outer end of cell *1st* M_2 and fork of vein M_{1+2}; veins brown. Venation: As in the *parishi* group; *Rs* arcuated; cell M_2 short; *m-cu* just beyond midlength of M_{3+4}.

Abdomen reddish yellow, the subterminal segments blackened; hypopygium yellow; basal tergites narrowly darkened laterally. Male hypopygium with the caudal margin of tergite very feebly emarginate to nearly transverse, the lateral lobes densely set with a continuous series of short black spines. Outer dististyle a glabrous clavate lobe. Inner dististyle broad, the apical beak narrow. Sternite with a transverse oval pale lobe that is densely covered with retrorse setae.

HABITAT: Mexico (Chiapas). *Holotype*, ♂, Finca Vergel, altitude 800 meters, June 3, 1935 (A. M. Dampf); M. F. 4416.

The most similar species is *Tipula smithi* Alexander, of southern Brazil, which has the antennal flagellum unicolorous, the pleura and coxae pruinose, and the wing pattern slightly different, with the dark seams at and beyond cord narrower and more broken and with cell R_5 chiefly pale to the margin.

Tipula novaleonensis sp. n.

Belongs to the *glaphyroptera* group; size large (wing, male, about 20 mm.); general coloration of mesonotum gray, the praescutum with four darker gray stripes; antennae relatively short, basal three segments yellow, the succeeding segments bicolored; knob of halteres dark brown; femora brown, the tips blackened, preceded by a very vague yellow ring; wings whitish subhyaline, heavily patterned with brown; prearcular and costal regions brighter yellow; abdominal segments reddish yellow, trivittate with dark brown; male hypopygium with the gonapophyses jutting from the genital chamber as curved yellow hooks; eighth sternite bearing a median tongue-like lobe.

Male.—Length about 17–18 mm.; wing, 19–21 mm.; antenna about 4 mm.

Frontal prolongation of head brownish gray, more blackened laterally; nasus elongate; palpi black. Antennae of moderate length; basal three segments yellow, succeeding two to four flagellar segments bicolored, the basal enlargement black, the stem yellow; outer segments uniformly black; flagellar segments with conspicuous basal enlargements; verticils a little shorter than the segments. Head gray, more buffy in front; a capillary blackened median area, broadest on the low vertical tubercle, interrupted and capillary behind; sides of posterior vertex dusky, the orbits paler.

Pronotum gray, variegated with brown. Mesonotal praescutum light gray with four poorly defined darker gray stripes, the lateral mar-

gins darker brown; scutum gray, each lobe with two darker gray areas; scutellum gray, parascutella darker; mediotergite light gray, with a capillary dark brown median line. Pleura light gray, variegated with darker gray on anepisternum, ventral sternopleurite and ventral meron; dorsopleural membrane more buffy. Halteres with stem elongate, yellow; knob dark brown. Legs with the coxae gray; trochanters yellow; femora brown, brightened basally, the tips blackened, preceded by a subequal, poorly defined, yellow ring; tibiae light brown, the tips darkened; tarsi black. Wings with the ground color whitish subhyaline, heavily patterned with brown; prearcular region and cells *C* and *Sc* more yellowish; ground color predominating in cells *R* and *M*, the former with a linear dash terminating at origin of *Rs*, the latter with two brown clouds at midlength and at outer end; cells beyond cord chiefly darkened, variegated by an incomplete white crossband beyond stigma, through cell *1st* M_2 into cell M_3; distal end of cell R_5 extensively brightened, of cells M_1 to *2nd A* less extensively so; cells *Cu* and the anals about equally white and brown, the axillary region brightened; veins brown, brightened in the yellow areas. Venation: *Rs* long, about one-half longer than *m-cu*; tip of R_{1+2} pale but entire; cell M_1 deep, its petiole shorter than *m*.

Abdominal tergites and sternites reddish yellow, trivittate with dark brown, the outer segments more uniformly darkened; hypopygium reddish brown. Male hypopygium with the tergite extensive, the caudal margin with a very broad U-shaped incision, the lateral lobes obtusely truncated; median area with a linear incision. Dististyle single, long and conspicuous, bearing a long pale arm on outer margin, this nearly as long as the style itself, the base parallel-sided, the apex weakly expanded. Gonapophyses appearing as strongly curved yellow hooks that jut from the genital chamber. Eighth sternite bearing a conspicuous median tongue-like lobe, broadest basally, narrowed to the obtuse tip, the length about three times the width at base.

HABITAT: Mexico (Nuevo Leon). *Holotype*, ♂, Cerro Potosi, altitude 12,500 feet, July 13, 1938 (H. Hoogstraal). Paratopotypes, 5 ♂♂, altitude 12,000–12,500 feet, July 13, 1938.

Tipula novaleonensis is quite distinct from all other large-sized members of the *glaphyroptera* group. The structure of the male hypopygium, especially of the dististyle and gonapophyses, is very different from other generally similar species.

Tipula pritchardi sp. n.

General coloration of mesonotum light reddish brown, the praescutum with faintly indicated darker stripes; antennae (male) relatively elongate; femora yellow, tibiae and tarsi brownish black; wings with a weak brownish tinge, the costal border and stigma darker; abdomen obscure yellow, the caudal borders of tergites two to four narrowly darkened, segments five and six unmarked or virtually so, segment seven black, segments eight and nine yellow; male hypopygium with the lat-

eral tergal lobes elongate, tufted with black setae; inner dististyle conspicuously blackened, the outer lateral angle produced into a slender, nearly straight rod; eighth sternite with the submedian lobes only narrowly separated by pale membrane.

Male.—Length about 14–15 mm.; wing, 13.5–14 mm.; antenna about 5.8–6 mm.

Female.—Length about 17–18 mm.; wing, 14–15 mm.

Frontal prolongation of head yellow, of moderate length; nasus distinct; palpi yellow. Antennae (male) relatively long, if bent backward ending about opposite midlength of the second abdominal segment; basal three segments yellow, remainder black; flagellar segments gently incised; verticils short. Head brownish yellow; vertical tubercle low.

Mesonotum chiefly light reddish brown, the praescutum with faintly indicated slightly darker stripes, the capillary median one especially distinct and slightly double; scutellum a little more testaceous. Pleura yellow, sparsely pruinose. Halteres relatively elongate, stem obscure yellow, knob dark brown. Legs with the coxae and trochanters yellow; femora obscure yellow; tibiae and tarsi brownish black. Wings with a weak brown tinge, the prearcular field, cells *C* and *Sc*, and the stigma darker brown; wing-tip in radial field slightly darker than remainder of ground; obliterative areas restricted in size; veins yellowish brown. Venation: R_{1+2} entire; *Rs* relatively long, nearly one-half longer than *m-cu*; petiole of cell M_1 longer than *m*; cell *2nd A* of moderate width.

Abdomen obscure yellow, the caudal borders of segments two to four, inclusive, narrowly darkened; segments five and six less distinctly patterned to virtually immaculate; segment seven black; segments eight and nine yellow. Male hypopygium with the tergite bearing three tufts of relatively short black setae, the lateral pair from slightly elongate lobes. Basistyle with a squamose blackened lobe on mesal face. Outer dististyle simple, sparsely setiferous. Inner dististyle conspicuously blackened, the outer lateral angle produced into a slender, nearly straight rod. Eighth sternite with the submedian lobes conspicuously tufted with blackened setae, rather narrowly separated by pale membrane. Ovipositor with cerci somewhat fleshy to feebly sclerotized, the tips obtusely rounded.

HABITAT: Mexico (Guerrero). *Holotype*, ♂, Taxco, June 30, 1935 (A. E. Pritchard). *Allotopotype*, ♀, pinned with type. *Paratopotypes*, 6 ♂ ♀.

Tipula pritchardi is named in honor of the collector, student of the Dipterous families Asilidae and Cecidomyidae. It is not closely allied to other regional species with the exception of *T. guerreroensis* sp. n., next described.

Tipula guerreroensis sp. n.

Male.—Length about 14 mm.; wing, 13.5–14 mm.; antenna about 6.5 mm.

Most closely allied and generally similar to *Tipula pritchardi* sp. n., differing as follows: Incisures of more basal flagellar segments slightly

more brightened. Mesonotal praescutum more pruinose, especially in the paratype where the coloration is chiefly light gray. Wings with *Rs* shorter and more oblique. Male hypopygium with the lateral lobes of tergite short, with tufts of short black setae; median tergal lobe small. Inner dististyle with the apical beak long and slender, bifid at tip, without a blackened outer rod as in *pritchardi*. Eighth sternite with the lateral hair tufts more widely separated, the median area produced into a low obtuse lobe.

HABITAT: Mexico (Guerrero). *Holotype*, ♂, Taxco, June 30, 1935 (A. E. Pritchard). *Paratopotype*, ♂.

Limonia Meigen

Limonia (Rhipidia) gracilirama sp. n.

General coloration of mesonotum yellowish brown; pleura obscure yellow, with a narrow, dark brown, longitudinal stripe; antennae (male) with ten long-bipectinate segments, the longest branches approximately two-fifths the length of the entire flagellum; halteres pale throughout; wings whitish subhyaline, with a darkened, chiefly costal pattern; Sc_1 ending opposite two-thirds the length of *Rs*; *m-cu* at fork of *M*; abdomen weakly bicolored, obscure yellow, with the distal third of individual segments dark brown; male hypopygium with ventromesal lobe of basistyle dark-colored, terminating in two fasciculate setae; rostral prolongation of ventral dististyle long and slender, with two long straight spines at near midlength; gonapophyses with mesal-apical lobes slender, spine-like, blackened.

Male.—Length about 6.5 mm.; wing, 5.6 mm.; antenna about 3 mm.

Rostrum and palpi black. Antennae with scape black, pedicel dark brown; first and last flagellar segments black; intermediate segments with basal enlargements and branches black, the long apical pedicels abruptly white; first and last flagellar segments unbranched, intermediate ten segments with unusually slender branches, the longest (at near midlength of organ) exceeding four times the segment and approximately two-fifths the length of the entire flagellum; branches of second flagellar segment about three times the segment; terminal segment about one-half longer than the penultimate, its outer fifth pointed. Head dark gray; eyes broadly contiguous, head holoptic.

Pronotum brown. Mesonotum chiefly light yellowish brown, the posterior sclerites a very little darker. Pleura obscure yellow, with a narrow but conspicuous dark brown longitudinal stripe. Halteres pale throughout. Legs with coxae and trochanters yellow; remainder of legs broken. Wings whitish subhyaline, with a relatively heavy, chiefly costal, dark pattern consisting of five areas, the last stigmal; second area largest, fourth (at fork of *Sc*) smallest; cord and outer cells of wing weakly darkened; veins and macrotrichia dark. Venation: Sc_1 ending about opposite two-thirds the length of *Rs*, Sc_2 not far from its tip; R_2 and free tip of Sc_2 in transverse alignment; *Rs* long, about twice R_{2+3}; *m-cu* at fork of *M*.

Abdomen weakly bicolored, obscure yellow, with about the distal third or slightly more of the individual segments dark brown; hypopygium brownish yellow. Male hypopygium with the caudal margin of ninth tergite very shallowly emarginate. Basistyle with ventro-mesal lobe dusky, long and conspicuous, shaped somewhat as in *flabelliformis*, but with the apex less produced and pointed, with two fasciculate setae at and near apex. Dorsal dististyle shorter than in *flabelliformis*. Ventral dististyle small, its greatest length less than that of the dorsal dististyle; rostral prolongation long and slender, with two long straight spines placed close together at near midlength; apex of prolongation beyond spines only a little shorter than the length of the latter. Gonapophyses with mesal apical lobes slender, spine-like, blackened.

HABITAT: Mexico (Chiapas). *Holotype*, ♂, Finca Vergel, altitude 800 meters, May 18, 1935 (A. M. Dampf); M. F. 4203.

The nearest ally of the present fly is *Limonia* (*Rhipidia*) *flabelliformis* Alexander (Panama and southward) which has somewhat similar antennae but differs in the details of structure of the male hypopygium, especially the short rostral prolongation of the ventral dististyle, with the long spines placed far out toward the tip. As is the case in *flabelliformis*, the present fly seems to have developed races in which the length of the flagellar pectinations varies in the different groups.

Limonia (Rhipidia) gracilirama lassula subsp. n.

Male.—Length about 6 mm.; wing, 5.2 mm.; antenna about 2.8 mm.

Very similar to the typical form, differing especially in the structure of the antennae; flagellar branches much shorter, the longest (at near midlength of organ) about two and one-half times the length of the segment and less than one-fourth the length of the flagellum itself. Abdominal tergites more uniformly brownish black.

HABITAT: Mexico (Chiapas). *Holotype*, ♂, Finca Victoria, altitude 900 meters, June 28, 1935 (A. M. Dampf); M. F. 4693 B.

Limonia (Rhipidia) proliferata sp. n.

General coloration dark gray, variegated with narrow blackened lines; antennal flagellum with segments three to eleven bearing two branches of moderate length, together with a small basal tubercle on flagellar segments three to ten; wings yellow, with an unusually heavy dotted, pale brown pattern; Sc_1 ending about opposite midlength of *Rs*; *m-cu* before fork of *M*; male hypopygium with rostral spines very short, pale.

Male.—Length about 7 mm.; wing, 7.7 mm.; antenna about 2.2 mm.

Rostrum brownish black, sparsely pruinose; palpi black. Antennae relatively short; scape and pedicel black; bases and branches of flagellar segments black, the apical pedicels pale; basal two flagellar segments

without branches; flagellar segments three to eleven, inclusive, each with two long branches and a short additional basal tubercle, the longest branches (about midlength of organ) about twice the length of the segment, the longest tubercle about one-third the length of the basal enlargement; eleventh flagellar segment with two short branches only; terminal segment relatively short, strongly constricted before apex. Head dark gray; anterior vertex reduced to a linear strip.

Pronotum brownish gray. Mesonotum dark gray, the praescutum indistinctly lined with blackish, including a short median vitta and more broken lines in the interspaces; pseudosutural foveae black, punctiform; scutal lobes more evidently marked with brown, the median area and the scutellum pale, pruinose; postnotum pruinose. Pleura dark gray, sparsely variegated with blackish. Halteres obscure yellow. Legs with the coxae reddish brown; trochanters obscure yellow; remainder of legs pale brown, the terminal tarsal segments more blackened. Wings with the ground color yellow, chiefly obliterated by an unusually abundant and heavy pale brown dotted pattern that is more extensive than the ground; very small and scarcely differentiated darker brown spots at origin of *Rs*, fork of *Sc*, R_2, along cord and outer end of cell *1st* M_2, and less evidently at ends of longitudinal veins; veins brown, those of basal half of wing more brownish yellow. Venation: *Sc* relatively long, Sc_1 ending about opposite midlength of *Rs*, Sc_2 near its tip; *Rs* long, weakly angulated at origin; free tip of Sc_2 and R_2 in transverse alignment; cell *1st* M_2 about as long as vein M_3 beyond it; *m-cu* about one-fifth its length before fork of *M*.

Abdominal tergites dark brown, sparsely pruinose; sternites obscure yellow, a little more darkened at the incisures. Male hypopygium with the caudal margin of tergite transverse or very feebly notched. Lobe of basistyle unmodified. Dorsal dististyle a nearly straight to gently curved rod, its apex abruptly narrowed into a straight spine. Ventral dististyle relatively small, the rostral prolongation long and gently curved; rostral spines short and straight, from small individual tubercles, subequal in length; apex of rostrum beyond outer spine a little longer than the length of the spine. Gonapophyses with mesal apical lobes appearing as blackened points.

HABITAT: Mexico (Chiapas). *Holotype*, ♂, Finca Vergel, altitude 800 meters, July 2, 1935 (A. M. Dampf); M. F. 4744.

Limonia (*Rhipidia*) *proliferata* agrees with species such as *L.* (*R.*) *inaequipectinata* Alexander (Argentina), *L.* (*R.*) *longurio* Alexander (Brazil) and *L.* (*R.*) *tripectinata* Alexander (Colombia) in the short basal tubercle on the flagellar branches, additional to the branches. It differs from all the above in the abundantly dotted wings and in the structure of the male hypopygium.

Limonia (Geranomyia) orthorhabda sp. n.

General coloration reddish brown, the praescutum with three narrow brownish black stripes; femora obscure yellow with a narrow brownish black subterminal ring; tibiae very narrowly darkened just before tips;

wings brownish yellow, patterned with brown, including a more conspicuous subcostal series, the areas at origin of *Rs* and fork of *Sc* barely disconnected; Sc_1 ending about opposite one-third the length of *Rs*; abdominal tergites dark reddish brown, the sternites yellow; male hypopygium with the ventral dististyle relatively small, with an unusually long, slender rostral prolongation; spines two, elongate, from conspicuous basal tubercles, black and nearly equal in length; mesal apical lobes of gonapophyses tufted with small setulae at apex.

Male.—Length, excluding rostrum, about 9 mm.; wing, 8 mm.; rostrum about 3.4 mm.

Rostrum relatively long, black, the paraglossae paling at tips. Antennae with scape and pedicel black, flagellum pale yellowish brown, the outer segments somewhat darker; flagellar segments oval, verticils short. Head blackish, the anterior vertex more silvery.

Pronotum dark brown. Mesonotal praescutum reddish brown with three narrow brownish black stripes, the median one slightly wider and more intense; posterior sclerites of notum more darkened. Pleura darkened on dorsal portion, the sternopleurite more reddish. Halteres with stem yellow, knob dark brown. Legs with the coxae and trochanters yellow; femora obscure yellow, with a narrow brownish black subterminal ring that is a trifle wider than the clearer yellow apex; tibiae brownish yellow, very narrowly infuscated immediately before tip; basal three tarsal segments obscure yellow, the tips narrowly dark brown, most extensive on third segment; terminal tarsal segments uniformly blackened. Wings with the ground color brownish yellow, patterned with brown; prearcular and costal regions deeper yellow; a dark spotted pattern, as follows: Above arculus; second spot at supernumerary crossvein in cell *Sc*; barely disconnected areas at origin of *Rs* and tip of *Sc*; stigma; cord and outer end of cell *1st* M_2; small marginal clouds at ends of veins R_3, *1st A* and *2nd A*; a faint dusky wash in cell *R*, interconnecting the second and third subcostal areas; veins yellow, darker in the clouded areas. Venation: Sc_1 ending about opposite one-third to two-fifths the length of *Rs*, Sc_2 at its tip; *r-m* greatly reduced by approximation of veins R_{4+5} and M_{1+2}, especially the former; cell *1st* M_2 closed; *m-cu* shortly beyond fork of *M*.

Abdominal tergites dark reddish brown, a little darker laterally, the outer segments more uniformly darkened; sternites yellow; hypopygium brownish yellow. Male hypopygium with the caudal margin of tergite slightly emarginate. Dorsal dististyle a somewhat angularly bent darkened rod, the tip strongly decurved. Ventral dististyle relatively small; rostral prolongation long and slender, only a little shorter than the dorsal dististyle; two rostral spines arising near base of prolongation, from slender basal tubercles placed a short distance apart; rostral spines black, subequal in length, nearly straight, of unusual length, each about two-thirds as long as the dorsal dististyle. Gonapophyses with mesal-apical lobes conspicuous, gently curved to the acute tips which bear numerous small delicate setulae; main body of apophysis narrow.

HABITAT: Mexico (Nuevo Leon). *Holotype*, ♂, Horse-tail Falls, June 15, 1938 (H. Hoogstraal).

Limonia (*Geranomyia*) *orthorhabda* is most similar to *L.* (*G.*) *platensis* (Alexander) and *L.* (*G.*) *separata* (Alexander), differing most evidently and conspicuously in the structure of the male hypopygium.

Orimarga Osten Sacken

Orimarga (Orimarga) niveitarsis majuscula subsp. n.

Female.—Length about 10.5 mm.; wing, 5.4 mm.

As in typical *niveitarsis* Alexander, of Panama (Proc. U. S. Nat. Mus., 48: 443–444; 1915), differing in the larger size and in details of coloration and venation. Coxae black; basal three-fifths of basitarsus black, the remainder abruptly white. Wings with a slight dusky tinge, the prearcular field not brightened. Macrotrichia of veins more abundant, including a complete series on vein M_4. Venation: R_2 lying distad of *r-m*. Abdomen elongate, with strong purplish reflections.

HABITAT: Mexico (Chiapas). *Holotype*, ♀, Santa Isabel, altitude 815 meters, November 17, 1930 (A. M. Dampf); M. F. 1906.

Orimarga (Diotrepha) subconcinna sp. n.

General coloration brown to dark brown; legs whitish; wings narrow, strongly tinged with brown, deepest in the stigmal area and the posterior prearcular field; basal half of costal field whitish; *Rs* about one-fourth longer than its anterior branch; abdomen brownish black to black.

Male.—Length about 7.5–9 mm.; wing, 4.5–5.5 mm.

Female.—Length about 7.5–8.5 mm.; wing, 5.5–6 mm.

Rostrum and palpi dark brown. Antennae dark brown throughout. Head dark brown, the anterior vertex and orbits narrowly gray.

Pronotum and cervical region black. Mesonotum and pleura almost uniform brown to dark plumbeous brown. Halteres dusky. Legs with the coxae and trochanters pale, the fore coxae a trifle darker; remainder of legs whitish; claws simple. Wings narrow, strongly tinged with brown, the basal half of the costal field whitish, gradually deepening in color, most saturated in the stigmal area; wing base, especially the posterior prearcular field and base of cell *1st A*, darkened; veins brown. Macrotrichia of veins very restricted, including short series on distal ends of veins R_{4+5} and M_{1+2}. Venation: R_{1+2} variable in length, from shorter than R_{2+3} to slightly longer than this vein; free tip of Sc_2 pale but evident, nearly opposite fork of *Rs*; Sc_2 ending opposite or just beyond one-third the length of *Rs*, the latter only about one-fourth longer than its anterior branch.

Abdomen brownish black to black throughout.

HABITAT: Mexico (Chiapas). *Holotype*, ♂, Finca Vergel, altitude 800 meters, May 23, 1935 (A. M. Dampf); M. F. 4268. *Allotopotype*, ♀. *Paratotypes*, ♂, ♀, May 11–23, 1935; M. F. 4123, 4132, 4152, 4267, 4268.

Orimarga (*Diotrepha*) *subconcinna* is closest to *O.* (*D.*) *concinna* (Williston), of St. Vincent. The original description of the latter species is insufficient but supplementary notes on the type provided by Dr. F. W. Edwards have been published elsewhere by the present writer (Proc. Acad. Nat. Sci. Philadelphia, 1921: 58). The present fly differs especially in the coloration of the wings and body and in the details of venation, as the relatively long outer radial cells in comparison with the length of *Rs*.

Polymera Wiedemann

Polymera (Polymera) leucopeza sp. n.

General coloration of mesonotum uniformly light brown; a narrow black pleural stripe, ventral pleura yellow; antennae (male) a little longer than the wing, black throughout, all but the last two flagellar segments binodose; femora beyond base uniformly darkened; fore and middle basitarsi black, the extreme tips and remainder of tarsi white; posterior basitarsi entirely white; wings with a very strong brown tinge; *Sc* relatively short, Sc_1 ending opposite or before midlength of R_{2+3+4}; R_{2+3+4} and R_5 subequal in length; abdomen, including hypopygium, black.

Male.—Length about 4.5–5 mm.; wing, 5–5.8 mm.; antenna about 5.5–6.2 mm.

Female.—Length about 5–5.5 mm.; wing, 5.5–6 mm.

Rostrum obscure yellow, palpi a little darker. Antennae (male) elongate, a little longer than the wing, black throughout; flagellar segments moderately elongate, strongly binodose to the penultimate segment, the last two segments short and simple. Antennae (female) short, black throughout. Head dark brownish gray.

Mesonotum uniformly light brown. Pleura and dorsal portion concolorous with the notum, the central portion occupied by a narrow but very conspicuous black stripe; ventral pleura light yellow. Halteres with stem pale, yellow at base, knob infuscated. Legs with coxae light yellow, the fore pair darkened basally; trochanters yellow; femora brownish black, the bases restrictedly brightened; tibiae black; fore and middle basitarsi black except at extreme outer ends; posterior basitarsi entirely snowy white; remainder of tarsi white, only the terminal segment darkened. Wings with a very strong brown tinge, the prearcular region a trifle brightened; veins and macrotrichia dark brown. Venation: *Sc* relatively short, Sc_1 ending opposite or before midlength of R_{2+3+4}, Sc_2 near its tip; R_{2+3+4} long, straight, subequal to *Rs*; R_{2+3} from one and one-half to nearly two times the length of R_{2+3+4}; cell M_1 moderately deep.

Abdomen, including hypopygium, black.

HABITAT: Mexico (Chiapas). *Holotype*, ♂, Finca Victoria, altitude about 900 meters, June 28, 1935, at lantern, 8–11 P. M.

(A. M. Dampf); M. F. 4693. *Allotopotype*, ♀, with the type. *Paratopotypes*, ♂ ♀, June 28–29, 1935; M. F. 4693 B, 4710 A, 4710 B. *Paratypes*, ♂ ♀, Finca Vergel, May 13–June 4, 1935, at light (A. M. Dampf); M. F. 4152, 4353, 4386, 4399, 4430.

The most similar species, having all tarsi more or less whitened and with a dark pleural stripe, are *Polymera* (*Polymera*) *albitarsis* Williston (Lesser Antilles) and *P.* (*P.*) *fusca* Wiedemann (Brazil). The former differs in the coloration of the legs, the dark color of the fore and middle legs involving not only all of the basitarsi but the proximal end of the second tarsal segment, while the posterior basitarsi are similarly darkened. The type specimen of *fusca* was studied by me in 1922. This species has *Sc* unusually long, ending some distance beyond the origin of vein R_{2+3}, the latter and all other veins beyond the cord of unusual length, the cord being placed close to midlength of the wing.

Polymera (Polymera) honesta sp. n.

Mesonotum brown, vaguely patterned with darker; pleura chiefly black; antennae (male) about one-half longer than the body, the basal flagellar segments bicolored; halteres infuscated; femora brownish black, the tips narrowly and abruptly white; all tarsi more or less white, on the posterior legs including virtually the entire tarsus; wings with a weak brown tinge, conspicuously spotted with brown on the cord and on outer forks; Sc_1 ending opposite fork of R_{2+3+4}; abdomen, including hypopygium, black.

Male.—Length about 5.5–5.7 mm.; wing, 5.5–6 mm.; antenna about 8.5–9 mm.

Rostrum obscure yellow; palpi black. Antennae (male) elongate, more than one-half longer than the body; scape and pedicel obscure yellow; basal flagellar segments bicolored, dark brown, the apical pedicel restrictedly pale; outer flagellar segments more uniformly darkened; flagellar segments conspicuously binodose, the terminal four or five more simple and elongate. Head dark brownish gray, the vertex marked with narrow blackish lines.

Pronotum pale yellow. Mesonotal praescutum brown, vaguely patterned with darker brown; scutal lobes darkened; scutellum dark brown; postnotum chiefly blackened. Pleura black dorsally, a trifle paler, more brownish black, on the ventral portion. Halteres infuscated, the base of stem restrictedly pale. Legs with the fore coxae brownish black, remaining coxae yellow; trochanters yellow; femora brownish black, the tips narrowly but conspicuously white; tibiae black, the extreme bases whitened; all tarsi more or less whitened, the fore and middle pairs including the tips of the basitarsi and segments two to four, inclusive; posterior tarsi white, with the exception of the last segment and a weak infuscation on proximal portion of basitarsi. Wings with a weak brown tinge, conspicuously spotted with brown, including seams along cord,

forks of R_{2+3+4} and M_{3+4}, and on vein R_2; basal fourth of wing more uniformly darkened; veins and macrotrichia dark. Venation: Sc_1 ending opposite fork of R_{2+3+4}, Sc_2 at its tip; *Rs* and R_{2+3+4} subequal, either about one-third R_{2+3}; cell M_1 small.

Abdomen, including hypopygium, black.

HABITAT: Mexico (Chiapas). *Holotype*, ♂, No. 4565, no further data available. *Paratype*, ♂, Finca Victoria, altitude 900 meters, June 29, 1935 (A. M. Dampf); M. F. 4709.

The wing pattern of the present fly is much as in *Polymera* (*Polymera*) *obscura* Macquart, but the pattern of the legs is quite different. The coloration of the femora is much like that of *P.* (*P.*) *geniculata* Alexander and *P.* (*P.*) *albogeniculata* Alexander, in both of which the wings are unpatterned.

Polymera (Polymera) nodulifera sp. n.

General coloration of mesonotum reddish brown, unpatterned; antennae (male) relatively short, only a little longer than the body; flagellar segments fusiform, with a conspicuous basal swelling only; dorsal pleura with a broad black longitudinal stripe; legs brown, the outer end of tibiae and the tarsi paling to yellowish white; wings with a weak brown tinge; *Rs* about one-half to two-thirds longer than R_{2+3+4}.

Male.—Length about 5 mm.; wing, 5 mm.; antenna about 6 mm.

Female.—Length about 5 mm.; wing, 4.5 mm.

Rostrum brownish yellow; palpi black. Antennae (male) a little longer than the body; basal two segments black; flagellum weakly bicolored, the basal enlargement dark brown, the pedicels obscure yellow; flagellar segments with basal enlargement only, the apical pedicel gradually narrowed to distal end, nearly twice as long as the swelling; terminal segment simple or with the basal enlargement barely indicated. Head brownish gray; eyes (male) large; vertex reduced to a linear strip; eyes (female) smaller.

Mesonotum uniformly reddish brown, without pattern. Dorsal pleura with a very broad black longitudinal stripe; ventral pleura reddish brown. Halteres with stem pale, knob weakly darkened. Legs with coxae brownish testaceous; trochanters testaceous; femora brown; tibiae brown basally, the distal half or less paling to dirty yellowish white; tarsi yellowish white. Wings with a weak brown tinge; cells *C* and *Sc* a trifle more yellowish brown; veins pale brown. Venation: Sc_1 ending opposite or just before the fork of R_{2+3+4}; *Rs* about one-half to two-thirds longer than R_{2+3+4}; R_{1+2} a little exceeding *Rs*; *m-cu* a short distance beyond fork of *M*.

Abdomen (male) broken; of female brownish black, the valves of ovipositor elongate.

HABITAT: Mexico (Chiapas). *Holotype*, ♂, Finca Vergel, altitude 800 meters, June 6, 1935 (A. M. Dampf); M. F. 4457. *Allotopotype*, ♀, pinned with type. *Paratopotype*, ♀, June 4, 1935; M. F. 4430.

Polymera (*Polymera*) *nodulifera* is entirely distinct from all other described species of the genus in the simply nodulose antennae of the male sex. All other species have the male flagellum simple, binodose or trinodose.

Oxydiscus de Meijere

Oxydiscus (**Oxydiscus**) **mexicanus** sp. n.

General coloration dark brown; rostrum, palpi and antennae black throughout; wings (male) broad, whitish subhyaline, the stigma a trifle darker; cell M_1 present; vein *2nd A* ending opposite widest point of wing; male hypopygium with the spines at base of phallosome entirely pale, at apex a trifle expanded, the tip short-apiculate.

Male.—Length about 4.5 mm.; wing, 5 mm.

Rostrum and palpi black. Antennae black throughout; basal flagellar segments short and crowded, the outer segments slender, with conspicuous verticils. Head light brownish gray.

Pronotum and mesonotum almost uniformly dark brown, without stripes; lateral portions of praescutum before suture a little more brightened. Pleura dark brown. Halteres short, brown, the base of stem restrictedly yellow. Legs with the coxae dark brown; trochanters testaceous; remainder of legs brownish black. Wings (male) broad, whitish subhyaline, the stigma a trifle darker; veins brown. Macrotrichia of cells sparse, in outer ends of cells R_2 to M_3, inclusive. Venation: Sc_1 ending opposite fork of *Rs*, Sc_2 a short distance from its tip; cell M_1 present; *m-cu* about its own length beyond fork of *M*; vein *2nd A* ending opposite the widest part of wing.

Abdomen pale brown, darker laterally; a darker brown subterminal ring; hypopygium yellow. Male hypopygium with the outer dististyle terminating in two strong, gently curved spines, with a few tiny accessory denticles; a slender additional spine on lower or cephalic face of style at near three-fourths the length. Gonapophyses pale, their apices obtuse. Spines at base of phallosome entirely pale, at apex a trifle expanded into a slight bulb, the tip short-apiculate.

HABITAT: Mexico (Chiapas). *Holotype*, ♂, Finca Germania, altitude 1190 meters, June 20, 1935 (A. M. Dampf); M. F. 4571.

The only other described regional species is *Oxydiscus* (*Oxydiscus*) *costaricensis* (Alexander), which differs in the smaller size, coloration of body and wings, and in slight details of venation. In the latter species, the wings of the male are not expanded and vein *2nd A* ends before the widest point of the wing.

Oxydiscus (Oxydiscus) mexicanus acutissimus subsp. n.

Male.—Length about 4–4.2 mm.; wing, 4–4.4 mm.

Bearing a marked general resemblance to typical *mexicanus*, differing especially in the smaller size, more evident darkened stigmal area on wing, and especially in the structure of the male hypopygium. Spines at base of phallosome heavily sclerotized and consequently more readily visible in slide mounts, gradually narrowed into acute needle-like points.

HABITAT: Mexico (Chiapas). *Holotype*, ♂, Finca Victoria, altitude 900 meters, June 28–29, 1935 (A. M. Dampf); M. F. 4699. *Paratopotypes*, ♂ ♂; M. F. 4709. *Paratypes*, ♂ ♂, Finca Vergel, altitude 1000 meters, May 19, 1935; M. F. 4205; Finca Germania, altitude 1190 meters, June 20, 1935; M. F. 4571.

Hexatoma Latreille

Hexatoma (Eriocera) plumbeinota sp. n.

Mesonotum uniform plumbeous black, unmarked; pleura yellow, conspicuously striped with brownish black; legs pale brown, the tibiae darker; all basitarsi entirely snowy white; wings uniformly tinged with pale brown, unpatterned; R_2 very faintly indicated to virtually atrophied; *m-cu* beyond midlength of cell *1st* M_2; abdomen brownish black, the hypopygium a little brighter.

Male.—Length about 8 mm.; wing, 8.5 mm.; antenna about 1.5 mm.

Rostrum and palpi brownish black. Antennae (male) short, 7-segmented, dark brown, the scape and pedicel a trifle brighter; terminal segment a little shorter than the subequal fifth and sixth segments. Head dark plumbeous gray; anterior vertex broad, with low tubercle.

Mesonotum almost uniform plumbeous black, without pattern. Pleura obscure yellow, including the dorsopleural membrane; two conspicuous brownish black longitudinal stripes, the more dorsal extending from the cervical region across the anepisternum and dorsal pteropleurite to the postnotum; lower stripe occupying the ventral sternopleurite; cephalic portion of pleurotergite slightly brightened. Halteres dark brown, the extreme base of stem pale. Legs with the coxae and trochanters light yellow; femora pale brown to brownish yellow, the tips narrowly darkened; tibiae brown; tarsi snowy white, including the entire basitarsus of all legs, only the outer tarsal segment darkened. Wings uniformly tinged with pale brown, unpatterned, even the stigmal area not indicated; veins brown. Venation: Sc_1 ending beyond level of *r-m*, Sc_2 opposite fork of Rs; R_2 very faintly indicated, in one wing of the type quite atrophied; cell M_1 lacking; *m-cu* beyond midlength of cell *1st* M_2; cell *2nd A* relatively narrow.

Abdomen brownish black, the hypopygium a little brighter.

HABITAT: Mexico (Guerrero). *Holotype*, ♂, Taxco, June 30, 1935 (A. E. Pritchard).

Hexatoma (*Eriocera*) *plumbeinota* is entirely distinct from the other regional species of the so-called "Penthoptera" group. It is readily told by the unpatterned mesonotum, uniformly white basitarsi, and uniformly infumed wings. The most similar species is *H.* (*E.*) *melanolitha* (Alexander), having the mesonotum conspicuously patterned and with the proximal ends of the fore basitarsi darkened.

Trentepohlia Bigot

Trentepohlia (**Paramongoma**) **subleucoxena** sp. n.

General coloration yellow, the praescutum with three conspicuous brown stripes, the lateral pair crossing the suture and suffusing the scutal lobes, scutellum and postnotum; wings yellowish subhyaline, restrictedly patterned with brown, including a small triangular stigma; cell *1st* M_2 subequal in length to vein M_3 beyond it; abdominal tergites brown medially, paler on sides.

Female.—Length about 11 mm.; wing, 9.5 mm.

Rostrum yellow; palpi obscure yellow, the terminal segment black. Antennae with scape and pedicel yellow, flagellum brownish black; flagellar segments with short inconspicuous verticils. Head buffy brown; anterior vertex reduced to a very narrow strip.

Pronotum yellow. Mesonotal praescutum yellow with three conspicuous brown stripes, the median one ending some distance before the suture, the laterals crossing the suture and including the scutal lobes, confluent behind, leaving only the broad median area of the scutum and a median brightening at base of scutellum pale. Pleura yellow. Halteres pale brownish yellow. Legs with the coxae and trochanters yellow; remainder of legs broken. Wings wider than in *leucoxena*, yellowish subhyaline, restrictedly patterned with brown, including the small triangular stigma; paler brown washes along *Rs*, *Cu* and R_5; cells *C* and *Sc* more saturated yellow; veins pale brown. Venation: Cell *1st* M_2 larger than in *leucoxena*, equal in length to vein M_3, beyond it; *m-cu* a short distance before fork of *M*.

Abdominal tergites brown medially, paler on sides, becoming brighter yellow on the subterminal segments; sternites yellow.

HABITAT: Mexico (Chiapas). *Holotype*, ♀, San Cristobal, June 19, 1935 (A. M. Dampf); M. F. 4560.

Trentepohlia (*Paramongoma*) *subleucoxena* is generally similar to *T.* (*P.*) *leucoxena* Alexander, differing especially in the color of the mesonotum and in details of pattern and venation of the wings. Unfortunately, the legs with their characteristic pattern in this group of species, are broken in the present specimen.

Gonomyia Meigen

Gonomyia (Gonomyia) guerreroensis sp. n.

General coloration of mesonotum dark brownish gray, the caudal border of scutellum only slightly brightened; antennae and legs dark throughout; halteres elongate; wings almost uniformly tinged with brown, the stigmal region darker but diffuse; Sc_1 ending opposite origin of *Rs*, R_{2+3+4} very long; *m-cu* just before midlength of cell *1st* M_2; male hypopygium with the apical lobe of basistyle shorter than the dististyle, the latter terminating in a small, angularly bent, black hook.

Male.—Length about 5 mm.; wing, 5.5 mm.

Female.—Length about 5.5 mm.; wing, 5.5 mm.

Rostrum and palpi brownish black. Antennae black throughout; flagellar segments (male) with long verticils. Head light gray.

Pronotum yellow medially, gray on sides. Mesonotal praescutum chiefly dark brownish gray; lateral pretergites clear light yellow; posterior callosities of scutal lobes and the caudal border of scutellum restrictedly more obscure yellow. Pleura yellow, variegated with brownish gray on the anepisternum and ventral strenopleurite, the mesepimeron almost uniformly pale. Halteres elongate, stem yellow, knob abruptly dark brown. Legs with the fore coxae brownish gray, remaining coxae pale yellow; trochanters yellow; remainder of legs dark brown. Wings almost uniformly tinged with brown, the stigmal region a trifle darker; prearcular field and costal border a little more yellowish; veins brown. Venation: Sc_1 ending opposite origin of *Rs*, Sc_2 at its tip; R_{2+3+4} very long, about one-third longer than *Rs* and subequal to vein R_4 alone; *m-cu* just before midlength of cell *1st* M_2.

Abdominal tergites dark brown, sternites more obscure yellow. Male hypopygium somewhat as in *chiapasensis*; apical lobe of basistyle shorter than the dististyle, somewhat pointed at apex. Dististyle terminating in a small, angularly bent, black hook, at base of which is a single strong seta; apex of style obtusely truncated, with the usual two fasciculate setae. Phallosome terminating in a flattened curved blade, with a longer, slender, sickle-shaped arm that is directed cephalad, the long-extended point strongly caudad.

HABITAT: Mexico (Guerrero). *Holotype*, ♂, Taxco, June 30, 1935 (A. E. Pritchard). *Allotopotype*, ♀.

Gonomyia (*Gonomyia*) *guerreroensis* is most generally similar to *G.* (*G.*) *chiapasensis* Alexander, differing conspicuously in the details of structure of the male hypopygium, especially the dististyle and phallosome.

A REVISION OF THE NORTH AMERICAN SPECIES OF PTEROCHEILUS AND NOTES ON RELATED GENERA

(Hymenoptera, Vespidae)

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Some of the largest and most colorful vespoid wasps are contained in the little known genus *Pterocheilus*. Although North America is well represented in species, which total 31 at the present time as compared to about 66 from other parts of the world, the distribution is almost entirely western and the bulk of the species come from the arid regions of the southwest. This accounts for the many predominantly red and yellow species which fly in company with similarly colored wasps of the large related genus, *Odynerus*. In *Pterocheilus* the tendency which occurs frequently in insect genera of having a few relatively common and widespread species, and a large number of rare and localized species is accentuated. The rarity of specimens of the genus in any one collection, and particularly in the eastern states, where most of the work on vespids has been done, has resulted in scattered descriptions only and has left many species undescribed. Furthermore, a logical classification of the genus can be based only on structural characters, which are hardly mentioned in earlier descriptions.

I have been fortunate enough to have studied the collections of the U. S. National Museum, Museum of Comparative Zoology at Harvard, Academy of Natural Sciences at Philadelphia, California Academy of Sciences, Washington State College, Oregon State Agricultural College, Colorado State Agricultural College, and Pomona College. I have also had access to numerous private collections including those of J. Bequaert, P. H. Timberlake, E. G. Linsley, G. E. Bohart, C. D. Michener, and M. Cazier.

DISTRIBUTION

Pterocheilus has been recorded from all the faunal realms except the Neotropical, but it is represented by only a single species each in the Australian, Oriental and Ethiopian. The other sixty-three exotic species are distributed in the Palearctic

region as follows: ten in Siberia and N. E. Europe, four in Tibet and N. China, eleven in S. W. Asia and S. E. Europe, eight in Central Europe, eleven in Greece, Italy, and Spain, and nineteen in N. Africa. The North American fauna probably traces its origin to Europe by way of Siberia and Alaska. Of the thirty-one described species of North America, the great majority are found in the west and southwest. A few species range into the midwest and south, and a single capture of a Texan species has been made in North Carolina. A few species also occur in Mexico.

PHYLOGENY

The fimbriate labial palpi and mandibles have long been used to taxonomically isolate the genus *Pterocheilus*. Unfortunately for these criteria, two other odyneroid genera, *Pseudopterocheilus* and *Leptochiloides*, exhibit the same characters which they have apparently acquired independently. Furthermore, the transition between *Pterocheilus*, *Pseudochilus*, and *Odynerus* sensu stricto is inconveniently gradual. A further relationship is indicated with *Rhynchagris* which itself forms a link between *Synagris* and *Odynerus*. In my opinion *Pterocheilus* represents an odyneroid in which the female labial palpi have become fewer segmented, longer, stouter, and heavily fringed with coarse hairs. All of these modifications increased strength and efficiency for carrying earth in the construction of the nest. The hooked and simple types of male antenna appear to be derivations of the coiled type, paralleling the similar gradation in *Odynerus*. *Leptochiloides* with its four segmented fimbriate labial palpi appears to bear much the same relationship to *Odynerus* (*Leptochilus*) that *Pterocheilus* bears to *Odynerus* sensu stricto. *Pseudopterocheilus*, also with four segmented fimbriate labial palpi but with a short tongue, probably has a common ancestry with *Odynerus* (*Stenodynerus*).

HABITS

Life histories of only a few species of *Pterocheilus* have been worked out. A. v. Schulthess (1877, Faun. Ins. Helvetiae, Hymen, p. 120) records colonies of *phaleratus* nesting in sandy soil. Ferton (1910, Ann. Soc. Ent. Fr., 68: 419) describes the habits of the closely related species, *chevrieranus*, in southern France. The burrows are made in clay or hard sandy soil, the vertical galleries ending in single horizontal cells stocked with

caterpillars. The egg hangs from the ceiling by a short thread. The aerial nests of *Odynerus pulchellus* (Smith) which were stocked with spiders were wrongly ascribed by C. Horne and F. Smith (1870, Tr. Zool. Soc., Lond., 7: 168) to *Pterocheilus*. Isely (1913, Kans. Univ. Sci. Bul., 8: 233) gives a description of the nest of *quinquefasciatus*. The burrow in sandy soil led into two horizontal galleries, one of which ended in a single cell and the other in three. The eggs were suspended from the ceilings of the cells which were stocked with cutworms. Ahrens (1924, Rev. Russe Ent., 18: 175) made additional observations on *chevrieranus* and recorded provisioning with larvae of Psychidae. Similar life histories of Californian species have been worked out for *trichogaster*, *comptus*, and *flavobalteatus* by G. Bohart and J. McSwain, and for *mirandus* by C. Hicks. This material is contained in unpublished manuscripts. To summarize, *Pterocheilus* makes shallow vertical galleries terminating in one or more horizontal cells which are stocked with lepidopterous larvae and each cell provided with a single egg suspended by a thread from the ceiling. The nests are usually built in sandy soil and the entrance is without a chimney. The wasps nest both singly and in colonies. According to G. Bohart, the pendulous labial palpi of the female are used in carrying earth from the nest during its construction.

KEY TO THE PTEROCHEILUS-LIKE GENERA

1. Female labial palpus three segmented, second segment without abundant long hair; maxillary palpus five or six segmented; male antenna rolled apically (p. 167) ..... **Pseudochilus**
   Female labial palpus three or four segmented, second and third segment at least at base with abundant long hair; maxillary palpus five or six segmented; male antenna rolled, hooked, or simple apically 2
2. Tongue short, labial palpus four segmented, maxillary palpus six segmented; male antenna hooked apically (p. 164) ..... **Pseudopterocheilus**
   Tongue long, labial palpus three or four segmented 3
3. Female labial palpus three segmented, maxillary palpus five or six segmented; male antenna at least twelve segmented (p. 168) ..... **Pterocheilus**
   Female labial palpus four segmented with last three segments thickly haired; maxillary palpus six segmented; male antenna eleven segmented and simple apically (p. 165) ..... **Leptochiloides**

Genus **Pseudopterocheilus** Perkins

(Type, *Odynerus relictus* Perkins; Pl. II, fig. 18)

Pseudopterocheilus Perkins, 1901, Ent. Mo. Mag., 37: 266

Medium sized odyneroid wasps. Tongue short and much as in *Odynerus*; outer edges of female mandible fringed with long hairs; female mandible five toothed, male mandible four toothed; female labial palpus lengthened, four-segmented, last segment short, last three segments with long hairs; maxillary palpus six segmented; male antenna

thirteen segmented, the last two segments forming a small hook; vertex in female without pits. Front face of pronotum with two distinct oblique pits; notaulices absent; propodeum rounded laterally, without an enclosure. Base of second abdominal sternite without a median furrow.

Pseudopterocheilus is known only from the Hawaiian Islands. It appears to be most closely related to the subgenus *Stenodynerus* and may be a specialized offshoot from it. The short *Odynerus*-like tongue precludes any close relationship with *Pterocheilus* although the somewhat pendulous and long-haired labial palpi indicate a remarkable parallel development. Three species, *relictus*, *pterocheiloides*, and *congruus*, all described by Perkins, belong to this genus.

Leptochiloides Bohart, new genus

(Type, *Leptochiloides utahensis* Bohart; Pl. I, fig. 8; Pl. II, fig. 20)

Small sized, resembling certain *Odynerus* (subgenus *Leptochilus*). Tongue long; outer edges of female mandible and that of male to a lesser extent fringed with long hairs; mandible four toothed in both sexes, that of male with an appressed protuberance near the clypeus; female labial palpus four segmented, last two segments subequal and together about as long as second segment; last three segments flattened and with abundant long hair. Maxillary palpus six segmented, second and third segments subequal and longer than basal segment, last three segments shorter than second and third together. Male antenna eleven segmented, last segment bluntly rounded apically. Vertex and front face of pronotum without pits in either sex. Propodeum with concave posterior, sloping superior, and lateral faces separated by indistinct rounded ridges. Apical margins of first two abdominal tergites slightly raised and smooth. Basal median furrow of second sternite extending about half its length. Aedeagus moderately stout and apically simple; parameres slender, membranous, and sparsely covered with bristles.

Except for the plume-like female labial palpi and simple male antennae, every indication points to a relationship with the *Odynerus* subgenus, *Leptochilus*, from which it may have been derived. The formation of the clypeus in the male is almost identical with that found in the group to which *Odynerus congressus* Viereck belongs. The Hawaiian *Pseudopterocheilus*, which also has four segmented labial palpi, has a short tongue and five toothed mandibles (Pl. II, figs. 18, 20). The mandibular tubercle present in the male is unique in the Vespidae as far as I can determine. It does not appear to be a modified tooth and occurs on the broad outer surface of the mandible rather than on the edge. It gives the appearance of a tooth which has been shorn off to permit the mandible to close under the clypeus.

Leptochiloides utahensis Bohart, new species

(Pl. I, fig. 8; Pl. II, fig. 20)

Female.—Dark red; ocellar triangle, one spot in front and two spots behind on mesonotum, base of second sternite, black; spot on pronotal angle, spots on tegula, spot beneath, two spots each on scutellum and postscutellum, femora and tibiae partly, irregular apical margins of abdominal tergites except three and five, sternites two and four, creamy white; labial palpus, antenna, tarsi, wing venation, apical half of apical cell, brownish. Pubescence minute, silvery, appressed. Punctures moderately large but for most part well separated, occurring over most of body. Head thick, quadrate, clypeus of irregular outline, tapering to a tiny apical emargination; transverse pronotal carina obsolete, front face of pronotum with scattered punctures; propodeum with a concave posterior face, and convex dorso-lateral and lateral faces, the different faces separated by rounded angles; first two tergites with narrowly smooth and slightly raised apical margins; second tergite as seen from above about one and two-fifths as broad as long; second sternite with a shallow basal furrow extending two-thirds the length of the sternite; length to apex of second tergite 7 mm.

Holotype female, Bellevue, Washington Co., Utah (Coll. U. S. N. M.). Holotype returned to the U. S. National Museum.

Besides the four segmented labial palpi, *utahensis* also possesses distinctive clypeus, wing pattern, mandibles and antennae. Its *Leptochilus*-like appearance is enhanced by the reddish color and fine silvery pubescence. Although *utahensis* might conceivably be the female of *brevicornis* or *arizonae*, the different markings and widely separated localities make this improbable.

Leptochiloides arizonae Bohart, new species

Male.—Black; mandibular tubercle, clypeus basally, inter-antennal spot, spot in eye emargination, post-ocular spot, pronotum in front, mesopleural spot, tegula partly, legs partly, lateral spots on scutellum and postscutellum, irregular apical margins of first, second, fourth, and fifth tergites and second to fourth sternites, whitish; mandibles mostly, propodeum, legs partly, first tergite mostly, reddish; legs partly, second and following abdominal segments mostly, brownish; wings almost clear except for a brownish spot in distal half of apical cell. Pubescence appressed and silvery except on vertex where it is about one ocellus length. Puncturation moderate on head and thorax where punctures are nearly contiguous on second tergite. Clypeus about twice as broad as long, roundly incised apically, latero-apical margin sinuate; labial palpus apparently two segmented, the second segment very short; all segments of flagellum subequal in length. Pronotal angles sharp but obtuse, middle femur normal, scutellum slightly convex; postscutellum not serrate. Apex of second abdominal tergite slightly reflexed; genitalia with long slender membranous parameres sparsely covered with short

bristles over the entire surface and with a group of setae-like bristles at the extreme base, aedeagus moderately broad and with a gradually narrowed subapical neck; length to apex of second tergite 6 mm.

Holotype male, Arizona, (collection of the author).

The coarse puncturation and broad black and white clypeus should separate this species in the male from *brevicornis*. The extensive black and limited red markings distinguish it from *utahensis*. Only a single male specimen is known.

Leptochiloides brevicornis Bohart, new species

Male.—Clypeus, mandible mostly, first antennal segment in front, Y-shaped inter-antennal mark, lower orbit, post-ocular spot, legs mostly, prothorax in front, mesopleural spot, spot on tegula, lateral spots on scutellum and postscutellum, irregular apical margins of first, second, fourth, and fifth tergites and second to sixth sternites, whitish; antenna, mandibular tubercle, prothorax behind, sides and rear of thorax mostly, legs partly, abdomen largely, reddish; remainder of head, mesonotum, dark brown to black; wings smoky, apical cell clouded towards the apex. Pubescence fine and silvery, appressed except on vertex where it is about one ocellus length. Body evenly punctured, the punctures well separated. Clypeus about once and a half as broad as long, apex shallowly incised, latero-apical margin nearly straight; labial palpus four segmented, the terminal segment slightly shorter than subterminal, the two together slightly shorter than second segment; all segments of flagellum subequal in length, flagellum tapering gradually toward the base from the tenth segment. Pronotal angles obtuse, middle femur normal, scutellum slightly convex, postscutellum not serrate; length to apex of second tergite 6 mm.

Holotype male, Los Angeles Co., Calif. (Coquillett Collection in U. S. N. M.).

The entirely white clypeus, the white mark on the basal antennal segment, and the sparse puncturation of the second tergite should distinguish this species which is known only from a single male.

Genus **Pseudochilus** Saussure

(Type, *Pterochilus glabripalpis* Saussure; Pl. II, fig. 21)
Pseudochilus Saussure, 1856, Etud. Fam. Vespid., 3: 321

Medium sized to large wasps. Tongue of moderate length, somewhat longer than in most *Odynerus*; outer edge of mandible in female fringed with long hairs; mandible short and robust, five toothed in female, three toothed in male; female labial palpus moderately long, three segmented, not particularly flattened, sparsely covered with isolated bristles; maxillary palpus five or rarely six segmented; male antenna thirteen segmented and apically coiled.

Soika (1936, Ann. Mus. Civ. Storia Nat. Genova, 59: 63–68) has written a paper on this genus outlining its general characters, calling attention to synonymy, and describing a new species. Although he limits the genus to species having five segmented maxillary palpi, it seems to me a better plan to base the genus on the labial palpi, because in the closely related genus, *Pterocheilus*, the maxillary palpi are both five and six segmented.

Pseudochilus represents an odyneroid type in which the tongue and labial palpi are in the process of becoming lengthened and the latter have lost the fourth segment. It is intermediate between *Odynerus* and *Pterocheilus*. The genus apparently occurs only in Africa and contains such species as *glabripalpis* Saussure, *capensis* Saussure, *major* Saussure, *insignis* Saussure, *biglumis* Saussure, *asmarensis* Soika, and *aethiopicus* Soika.

Genus **Pterocheilus** Klug

(Type, *Vespa phalerata* Panzer; Pl. I, figs. 1, 2; Pl. II, fig. 1)
Pterocheilus Klug, 1805. Beitr. z. Naturkunde, 1: 143
Pterochilus Authors

Small to large odyneroid wasps. Tongue long and slender. Outer edges of mandible of female, and of male to a less extent, fringed with long hairs and four to five toothed; labial palpus three segmented (or in some males apparently two segmented), pendulous in the female and with the second and third segments clothed with very long hair; maxillary palpus five or six segmented; male antenna simple, hooked, or coiled apically.

The genus contains such a diverse assemblage of wasps that it is convenient to divide them into a number of natural subgenera of which three occur in the Nearctic Region. It is possible that further subgenera will need to be erected for some of the exotic types.

KEY TO THE SUBGENERA OF PTEROCHEILUS

1. Maxillary palpus five segmented; male labial palpus smaller but similar to that of female; male antenna rolled apically (p. 172)...**Pterocheilus** s. str.
   Maxillary palpus six segmented, male labial palpus much more slender and less hairy than that of female..... 2
2. Apical half of third segment of labial palpus constricted in both sexes and bare; front face of pronotum with two oblique pits; female mandible five toothed; male antenna rolled apically (p. 173).....**Hemipterochilus**
   Third segment of labial palpus not constricted apically and at least in female long haired throughout..... 3
3. Female mandible slender or even sickle-shaped, not more than four-dentate; small species, mostly 10 mm. or less in length; male antenna thirteen segmented and not curled or hooked apically (p. 201).....**Micropterocheilus**
   Female mandible stout and five-dentate; male antenna usually curled or hooked apically, if straight and thirteen segmented, the species are at least moderately large..... 4

4. Male antenna simple or rolled apically; female clypeus usually either strongly incised apically or truncate and slightly produced, the truncation being less than half as long as scape, clypeus usually roughened (p. 173), **Megapterocheilus**

Male antenna thirteen segmented and hooked apically, last two segments greatly reduced; female clypeus usually smooth and rounded or pointed apically, if truncate, truncation is more than half as long as scape (p. 191), **Onchopterocheilus**

KEY TO THE SPECIES OF PTEROCHEILUS IN NORTH AMERICA

Labial palpus small, filiform; clypeus broadly bordering compound eyes, its lateral angles obtuse ..... *males*

Labial palpus large, long, and flattened; clypeus narrowly bordering the compound eyes, its lateral angles acute (p. 171) ..... *females*

Males

1. Antenna twelve segmented or if thirteen segmented, last segment only is minute ..... **(Megapterocheilus)** 2

Antenna thirteen segmented, last two segments sometimes minute 6

2. Apex of clypeus strongly incised; antenna twelve segmented 3

Apex of clypeus truncate or weakly incised 4

3. Last antennal segment strongly pedicellate basally (p. 188) ..... **pedicellatus**

Last antennal segment not pedicellate (p. 187) ..... **quinquefasciatus**

4. Antenna thirteen segmented, last segment minute and flattened; average distance between punctures on anterior half of dorsulum greater than average diameter of punctures (p. 186) ..... **inyoensis**

Antenna twelve segmented; average distance between punctures on anterior half of dorsulum less than average diameter of punctures 5

5. First abdominal tergite with minute pubescence only; second tergite with a pair of pubescent brown spots dorsal to spiracles; last antennal segment slightly recurved and pointed (p. 190) ..... **mirandus**

First abdominal tergite with appressed pubescence and in addition with fine semi-erect hair; second tergite with a pair of dorso-lateral, spiracle-like depressions in addition to spiracles; last antennal segment not recurved and pointed (p. 189) ..... **biplagiatus**

6. Antenna with last two segments not greatly reduced 7

Antenna with last two segments greatly reduced ..... **(Onchopterocheilus)** 14

7. Last antennal segment strongly flattened, curved, and longer than twelfth, **(Megapterocheilus)** 8

Last antennal segment, if strongly flattened and curved, not longer than twelfth 11

8. Middle femur with a deep, sharp, channel-like incision along its outer face; hind tibiae strongly inflated apically (p. 180) ..... **denticulatus**

Middle femur, if modified, not deeply channeled; hind tibia normally enlarged apically 9

9. Middle femur strongly modified, with deep dorso-lateral and baso-ventral depression; clypeus truncate apically (p. 178) ..... **crispocornis**

Middle femur with a shallow basal depression only; clypeus deeply and roundly incised 10

10. Punctures of second tergite closely restricted, large, and separated by more than an average puncture diameter (p. 174) ..... **arizonicus**

Punctures of second tergite gradually diminishing anteriorly, moderate in size, and hardly separated by an average puncture diameter (p. 176), **linsleyi**

11. Body usually 10 mm. or more in length; third segment of labial palpus usually equal in length to two; volcellae of genitalia with numerous bristles along inner edges ..... **(Megapterocheilus)** 12

Body usually less than 10 mm. in length; third segment of labial palpus less than half as long as two; volcellae of genitalia with the bristles concentrated apically ..... **(Micropterocheilus)** 22

12. First abdominal tergite with abundant long hair; second tergite without a pair of dorso-lateral, spiracle-like depressions in addition to spiracles; last antennal segment pointed apically (p. 183)..... **trichogaster**
First abdominal tergite without abundant long hair; last antennal segment not pointed apically..... 13
13. Last antennal segment much flatter at base than twelfth segment at apex; spiracle-like pits of second tergite obscure; last segment of labial palpus about as long as second (p. 185)..... **texanus**
Last antennal segment hardly flatter at base than twelfth segment at apex; second abdominal tergite with a pair of prominent spiracle-like depressions in addition to the spiracles (p. 184)..... **decorus**
14. Middle femur with a distinct baso-ventral depression or shallow excavation extending more than half its length; yellow area of second tergite with a distinctly U-shaped anterior margin (p. 194)..... **timberlakei**
Middle femur without a distinct basal depression..... 15
15. Last two segments of antenna together about equal in length to eleventh segment..... 16
Last two segments of antenna together distinctly shorter than eleventh segment..... 19
16. Body almost entirely yellow, markings blackish and reddish (p. 197), **pimorum**
Body not mostly yellow..... 17
17. Apex of clypeus slightly convex; body markings yellowish (p. 196)..**micheneri**
Apex of clypeus very slightly convex, body markings whitish..... 18
18. Propodeum covered with long silky pubescence; abdomen finely punctate (p. 200)..... **hirsutipennis**
Propodeum covered with thick short pubescence; abdomen coarsely punctate (p. 192)..... **panamintensis**
19. Clypeus and sides of thorax clothed with erect fulvous hair; last two antennal segments not or hardly retracted within eleventh segment; largely black and yellow..... 20
Clypeus and sides of thorax clothed with fine, closely appressed, silvery-white pubescence; last two antennal segments partially or entirely retracted within eleventh segment; middle femur with rounded basal hump..... 21
20. Yellow band of second tergite with a curved anterior margin; last two antennal segments together less than half as long as eleventh (p. 199), **comptus**
Yellow band of second tergite with a squarely or obtusely angled anterior margin; last two antennal segments together about two-thirds as long as eleventh (p. 198)..... **bakeri**
21. Largely black and yellow, femora and tibiae without rufous marks (p. 193), **trachysomus**
Largely black and whitish, femora marked with rufous (p. 191)..... **laticeps**
22. Middle femur without a distinct baso-ventral depression..... 23
Middle femur with a distinct baso-ventral depression or shallow excavation..... 25
23. Abdominal segments rufous, narrowly margined with white....**diversicolor**[1]
Abdominal segments black, marked with white or yellow..... 24
24. Last antennal segment broadly rounded apically; femora marked with dark reddish, pale markings whitish, base of first abdominal segment rarely red (p. 202)..... **desertorum**
Last antennal segment pointed or narrowly rounded apically; femora without dark reddish markings, pale markings whitish or yellowish, (p. 203)..... **provancheri**
25. Basal depression extending about a third or less the femoral length; last antennal segment broadly flattened beneath..... 26
Basal depression extending distinctly more than one-third the femoral length; last antennal segment a curved cone (p. 205)..... **flavobalteatus**
26. Last antennal segment longer than broad at base as viewed from beneath; depression of mid-femur somewhat oblique; apex of clypeus not longer than apico-lateral side; abdominal tergites often dull (p. 205).... **morrisoni**

[1]Not treated in this revision.

Last antennal segment about as long as broad at base; depression of mid-femur not oblique; apex of clypeus longer than apico-lateral side; abdominal tergites shining, very sparsely punctured (p. 204).....**seneconis**

FEMALES

1. Mandibles stout and five-dentate, two basal teeth small but distinct..... 2
   Mandibles slender or even sickle-shaped, not more than four-dentate; small species.....**(Micropterocheilus)** 23
2. Clypeus not rounded or tapering to a point apically, either strongly incised or truncate and produced at tip, truncation less than half as long as scape; clypeus usually roughened.....**(Megapterocheilus)** 3
   Clypeus rounded or pointed apically; if truncate, truncation more than half as long as scape; clypeus often smooth and polished..**(Onchopterocheilus)** 16
3. Apex of clypeus strongly incised..... 4
   Apex of clypeus truncate or slightly concave..... 7
4. Punctures on second tergite restricted to a definite apical area, punctured and smooth areas sharply differentiated..... 5
   Punctures on second tergite extending gradually anteriorly..... 6
5. Second tergite largely yellow or yellow and reddish (p. 188).....**pedicellatus**
   Second tergite black, marked with yellow (p. 182).....**oregonensis**
6. Third tergite closely and moderately coarsely punctured; apex of clypeus with a fairly shallow smoothly rounded concavity (p. 176).....**linsleyi**
   Third tergite very finely punctured, apex of clypeus with a deep and somewhat angular notch (p. 187).....**quinquefasciatus**
7. First abdominal tergite haired, the hair erect or semi-erect and at least some of the hairs as long as the tenth antennal segment..... 8
   First abdominal tergite with minute pubescence or short appressed hair, the semi-erect hair when present shorter than the tenth antennal segment..... 10
8. Second tergite covered with almost contiguous moderate sized punctures; markings red, black and yellow (p. 180).....**denticulatus**
   Second tergite weakly and sparsely punctured; markings mainly black and yellow..... 9
9. Almost entire body covered with long pale hairs, clypeus strongly haired (p. 183).....**trichogaster**
   Hair on body short, clypeus almost bare (p. 189).....**biplagiatus**
10. Third and fourth abdominal tergites sparsely covered with relatively large punctures giving a pitted appearance; apex of clypeus shallowly incised (p. 174).....**arizonicus**
    Third and fourth abdominal tergites almost impunctured, or thickly covered with moderately large punctures..... 11
11. First two segments of abdomen largely orange, last three segments almost entirely black (p. 181).....**nigricaudus**
    Last few segments of abdomen marked with yellow or reddish..... 12
12. Body largely reddish, the wings blackish (p. 181).....**mexicanus**
    Body largely black or yellow, marked with whitish or reddish..... 13
13. Third tergite closely and moderately coarsely punctured (p. 185).....**texanus**
    Third tergite very finely punctured..... 14
14. Underside of front coxa black; mesopleuron usually with only one large spot below tegula; with a reddish pubescent spot latero-dorsally on second tergite (p. 184).....**decorus**
    Underside of front coxa marked with yellow; mesopleuron with two large yellow spots below tegula, or almost entirely yellow; without a reddish pubescent spot dorso-laterally on second tergite..... 15
15. Average distance between punctures on anterior half of dorsulum as great or greater than average diameter of punctures (p. 178).....**crispocornis**
    Average distance between punctures on anterior half of dorsulum much less than average diameter of punctures (p. 190).....**mirandus**
16. Femora black and yellow or entirely yellow..... 17
    Femora entirely red, other markings black and whitish (p. 191).....**laticeps**
17. Lateral angles of propodeum with a weak ridge or a carina (p. 194), **timberlakei**
    Lateral angles of propodeum rounded..... 18

18. Hair on frons at least as long as fourth antennal segment 19
Hair on frons shorter than fourth antennal segment 21
19. Abdomen thickly covered with minute silvery pubescence; wings thickly covered with relatively long hairs (p. 200) ..... **hirsutipennis**
Abdomen not thickly covered with minute silvery pubescence 20
20. Latero-apical edges of clypeus concave, particularly near apex; apex of clypeus sharply truncate (p. 198) ..... **bakeri**
Latero-apical edges of clypeus convex (p. 199) ..... **comptus**
21. Second abdominal segment almost entirely yellow, narrowly red at base; apex of clypeus almost straight (p. 197) ..... **pimorum**
Second abdominal segment with black markings; clypeus distinctly convex apically 22
22. Second abdominal tergite with very fine punctures at its middle (p. 196), **micheneri**
Second abdominal tergite with very coarse punctures at its middle (p. 193), **trachysomus**
23. Clypeus slightly produced and rounded apically 24
Clypeus truncate apically 25
24. Clypeus white, thorax black and white, abdomen red and white, propodeum red (p. 207) ..... **tricoloratus**
Clypeus yellow with apical third black; body black and yellow (p. 208), **acuceps**
25. Abdomen mostly reddish, marked with white; clypeus almost impunctate, **diversicolor**[1]
Abdomen black, marked with white or yellow 26
26. Clypeus entirely black; femora and tibiae marked with reddish (p. 202), **desertorum**
Clypeus rarely entirely black; femora and tibiae without reddish markings .. 27
27. Clypeus distinctly broader than long (1.3–1.6 times as broad as long); clypeus not margined with black except basally; markings yellow (p. 205) ..... **flavobalteatus**
Clypeus only slightly broader than long (1.0–1.3 times as broad as long); clypeus frequently margined with black on sides and apex; markings whitish or yellowish 28
28. Dark markings of venter brown; light markings of abdomen whitish, yellowish elsewhere; puncturation of second tergite except at apex almost obsolete; second tergite shining (p. 204) ..... **seneconis**
Dark markings of venter black; puncturation of second tergite often fine but thick; second tergite dull; markings black and whitish (subsp. **pruinosus,** p. 203) or yellowish (pp. 205 and 203) .. **morrisoni** and **provancheri**

Subgenus **Pterocheilus** sensu stricto

Small *Pterocheilus*. Male antenna coiled apically and thirteen segmented. Labial palpus three segmented, the last two segments flattened, clothed with long hair in both sexes and unusually pendulous in the male. Maxillary palpus five segmented. Mandibles five toothed and clypeus apically truncate in both sexes.

A quotation from the original description of the genus is as follows:

"Palpen vier, nicht ganz von gleicher Länge. Die vordern etwas kurzer, als die hintern, smächtiger, und von einer fishbeinähnlichen Substanz, haben fünf Glieder, alle cylindrisch, die beiden letzten etwas kurzer, als die ubrigen, das letzte abgerundet, das erste an die Spitze etwas verdicht. . . . Die hintern langer, starker und dreigliedricht; die Glieder unter sich von gleicher Länge, und die beiden ersten von einer hornartigen Substanz; das erste keulformig, nämlich an der Wurzel

[1]Not treated in this revision.

schmächtig, dünn, an der spitze stark verdicht, glatt und glanzend, das zweite umgekehrte keulformig, an der Wurzel stark verdicht, und gegen die Spitze dünn, auf beiden seiten mit langen, steifen, etwas einwarts gekrümmten Haaren dicht besetzt."

Notwithstanding Klug's statement that the maxillary palpus was five segmented, following authors seem to have disregarded this condition which characterizes the typical subgenus. The unusually large and hairy labial palpus of the male is also a distinguishing feature. The three species belonging to this subgenus which I have seen are *phaleratus* (Panzer) from Europe, *chevrieranus* Saussure from Europe, and *pharaonum* Schmiedeknecht from Egypt.

Subgenus **Hemipterochilus** Ferton

(Type, *Odynerus terricola* Mocsary; Pl. II, figs. 13, 22)
Hemipterochilus Ferton, 1909. Ann. Soc. Ent. Fr., 77: 572

Medium to large *Pterocheilus*. Male antenna coiled apically and thirteen segmented. Labial palpus three segmented, the last segment with its apical half in both sexes constricted and bare. Maxillary palpus six segmented. Female mandible five toothed.

Hemipterochilus occurs in Europe and includes such species as *invasor* Dusmet, *terricola* (Mocsary), *bembeciformis* Morawitz, and *nudiventris* Morawitz. These species are very similar in structure and appearance to some of the larger *Odynerus* sensu stricto (=*Hoplomerus*) of Europe and northern Africa.

Megapterocheilus Bohart, new subgenus

(Type, *Pterochilus mirandus* Cresson)

Relatively large *Pterocheilus*, 10 to 20 mm. in length. Male antenna simple or coiled apically and twelve or thirteen segmented. Labial palpus three segmented; the last two segments in the female subequal in length, flattened, and bearing numerous long hairs. Maxillary palpus six segmented. Female mandibles stout and distinctly five toothed. Female clypeus usually either strongly incised apically or truncate and slightly produced, the truncation being less than half the length of the scape.

In addition to the fourteen North American species, those of Eurasia and Africa which may be tentatively included in the subgenus are *pallasii* Klug, *anomodontus* Soika, *grandis* Lepeletier, *albofasciatus* Smith, *cyrenaica* Gribodo, and *moricei* Schulthess.

Certain of the American species are peculiar in having the male antennae only twelve segmented and uncurled. All intermediates exist between the two types and no correlated

differences are exhibited by the females. Also, in the American species the male aedeagus is characteristically constricted at the base and suddenly laterally expanded near the middle.

Pterocheilus arizonicus Bohart, new species

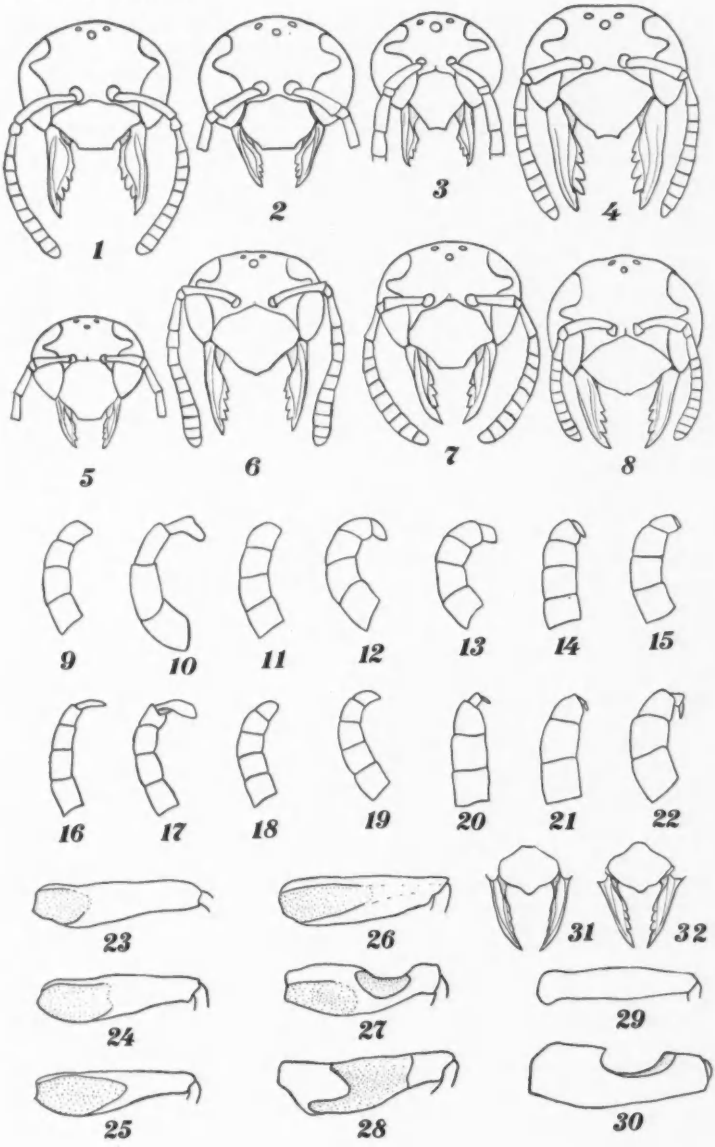
(Pl. II, fig. 14)

Male.—Reddish-brown; apical two and a half segments of antenna, front and vertex mostly, mesonotum medially, mesopleural spot, middle stripe on propodeum, first and second abdominal tergites at base, wing veins mostly, black; antenna beneath subapically and first segment, clypeus, inter-antennal spot, lower orbit, front of pronotum, mesopleural spot, postscutellum, legs in front, irregular apical bands on first and second tergites and second sternite, third and following segments except at extreme base, dull reddish-yellow; wings deeply brown-stained, darker apically, slightly violaceous. Head and thorax clothed with moderately thick but short golden pubescence, that of front one and a half ocellus lengths, that of mesonotum hardly one ocellus length; abdominal tergites thickly covered with golden pubescence, that on apex of first tergite about one and a half ocellus lengths. Clypeus obscurely punctured, slightly silvered; punctures of vertex and pronotum about one puncture diameter apart, mesonotum coarsely and closely punctured, propodeum with well separated punctures; abdominal tergites with well defined apical punctured areas, the punctures on tergites one to four becoming progressively larger, those of third and fourth tergites very coarse and covering entire exposed area but separated by one or two puncture diameters, apical margins of sternites two to five with small well separated punctures. Clypeus sharply and angularly incised apically, lateral and latero-apical sides about equal; antenna long, last segment flattened and pointed, twelfth segment conspicuously flattened; mandible five toothed; lateral angles of propodeum rounded; middle femur flattened basally and with a large shallow baso-ventral depression; second tergite as seen from above about once and a third as broad as long; length to apex of second tergite 14 mm.

Female.—Markings, pubescence, and puncturation about as in male with following exceptions: Antenna beneath and at base, front and vertex, mesonotum almost entirely, last abdominal tergite, reddish; spot on lateral angle of propodeum yellow. Outer sides of tibiae with twenty to thirty short reddish bristles in addition to pubescence.

EXPLANATION OF PLATE I

(1–8, front view of the head). 1, *phaleratus* female. 2, *phaleratus* male. 3, *mirandus* male. 4, *mirandus* female. 5, *micheneri* male. 6, *micheneri* female. 7, *desertorum* female. 8, *Leptochiloides utahensis* female. (9–22, ninth and following segments of male antenna, lateral view). 9, *quinquefascialus*. 10, *pedicellatus*. 11, *biplagiatus*. 12, *trichogaster*. 13, *decorus*. 14, *texanus*. 15, *inyoensis*. 16, *linsleyi*. 17, *denticulatus*. 18, *provancheri*. 19, *morrisoni*. 20, *bakeri*. 21, *comptus*. 22, *micheneri*. (23–29, ventral view of male middle femur). 23, *morrisoni*. 24, *cyathopus*. 25, *flavobalteatus*. 26, *mirandus*. 27, *crispocornis*. 28, *denticulatus*. 29, *trachysomus*. 30, *denticulatus*, dorsal view of male middle femur. 31, *tricoloratus* female clypeus and mandibles in front view. 32, *acuceps* female clypeus and mandibles in front view.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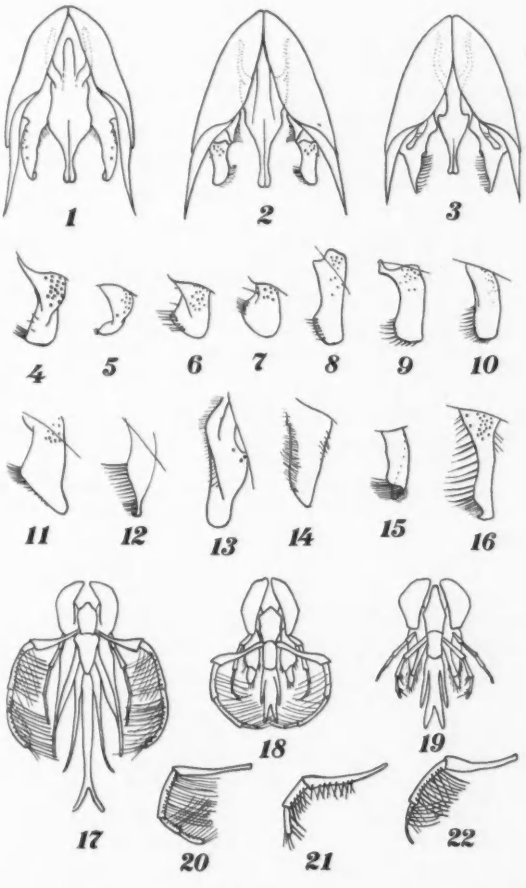
Clypeus narrowly sub-truncate, apex with a shallow angular emargination forming an angle of about 135 degrees, the apex as long as fifth antennal segment; length to apex of second tergite 15 mm.

Holotype male, and one male paratype, Pima Co., Arizona, July 27, 1927 (P. A. Readio); allotype female, Sabine Canyon, Santa California Mts., Arizona, August 23, 1933; one paratype female, 18 miles south of Tucson, Arizona, July 31, 1924 (E. P. Van Duzee); one paratype female, Willow Creek Mts., New Mexico, July, 1933. Holotype in University of Kansas collection, allotype in California Academy of Sciences, paratypes in collection of author.

This species is most closely related to *linsleyi*, but differs in the thicker and more golden pubescence of the abdomen, and in the character of the puncturation. In *arizonicus* the second tergite is shining and impunctured except for a restricted area containing relatively large punctures which are well separated. The puncturation of the second and following tergites is suggestive of that found in *Odynerus pratensis* Saussure.

Pterocheilus linsleyi Bohart, new species
(Pl. I, fig. 16)

Male.—Black; clypeus, first antennal segment in front, interantennal spot, stripe below emargination of eye, post-ocular stripe, front part of pronotum above, mesopleural spot, front legs in part, spot on hind coxa, postscutellum, irregular apical bands on all abdominal tergites except the last, free lateral spot on second tergite, incomplete apical bands on sternites two to six, yellow; antenna except last two segments and first segment in front, mandible, labial palpus, pronotum at sides and behind, spot on mesopleuron adjacent to yellow spot, scutellum, lateral angle of propodeum, legs for the most part, sub-basal lateral spots on tergites one and two, indistinct lateral spots on following tergites, indistinct markings on sternites, brownish red; wings stained with yellow, veins mostly reddish. Pubescence pale, sparse and appressed on clypeus, more than two ocellus lengths on front and propodeum, about one ocellus length on mesonotum and first abdominal tergite, pubescence of abdominal tergites for most part semi-erect, mostly less than one ocellus length on second and following tergites; tibiae with a few short bristles on outer sides in addition to pubescence. Clypeus very weakly punctured except toward apex, punctures of front and vertex separated by about one puncture diameter, those of mesonotum nearly contiguous, those of propodeum inconspicuous, those on apex of first abdominal tergite well separated, those of tergites two to four hardly one puncture diameter apart, second tergite with much larger punctures sub-basally than apically and with the sub-basal punctures almost contiguous, third tergite with median punctures the largest, fourth and following tergites with punctures concentrated apically, venter not strongly punctured. Antenna very long, thirteen segmented,



(1–3, male genitalia in dorsal view). 1, *phaleratus*. 2, *comptus*. 3, *mirandus*. (4–16, right volsella of male genitalia in dorsal view). 4, *flavobalteatus*. 5, *morrisoni*. 6, *provancheri*. 7, *desertorum*. 8, *hirsutipennis*. 9, *bakeri*. 10, *timberlakei*. 11, *trachysomus*. 12, *pimorum*. 13, *terricola*. 14, *arizonicus*. 15, *crispocornis*. 16, *denticulatus*. (17–19, female tongue in front view). 17, *morrisoni*. 18, *Pseudopterocheilus relictus*. 19, *Odynerus annulatus*. (20–22, female labial palpi). 20, *Leptochiloides utahensis*. 21, *Pseudochilus asmarensis*. 22, *terricola*.

first segment strongly compressed dorso-ventrally, following segments becoming gradually less flattened, last two segments each as long as eleventh, last segment curved but flattened and apically pointed; clypeus roughly heptagonal in addition to notched apex, lateral sides the longest, apex roundly incised, distance between apical teeth slightly more than half the length of the fourth antennal segment; mandible five toothed, last segment of labial palpus three quarters as long as second; middle femur flattened basally and with a large shallow baso-ventral depression; lateral angle of propodeum rounded, punctured areas of abdominal tergites hardly depressed; second tergite as viewed from above about one and two-fifths as broad as long; length to apex of second tergite 12 mm.

Female.—Markings, pubescence, and puncturation about as in male with following exceptions: Apical two-thirds of antenna black above, vertex and post-ocular regions mostly reddish, a large reddish spot on mesonotum, scutellum and lateral angle of propodeum mostly yellow, first and second abdominal tergites with restricted black markings, second tergite equally red and yellow, venter red marked with yellow. Outer sides of tibiae with twenty to forty short reddish bristles in addition to pubescence. Puncturation of front and clypeus more dense than in male, that of second and third abdominal tergites weaker. Clypeus roundly incised apically; length to apex of second tergite 13 mm.

Holotype male and allotype female, Alpine, Texas, June 10, 1930 (E. G. Linsley); three female paratypes, Sabinal, Texas, May, 1910 (F. C. Pratt); one female paratype, Texas, May 8 (Fouts); one female and twelve male paratypes, Cotulla, Texas, May, 1906, on *Verbesina encelioides* (F. C. Pratt and J. C. Crawford). Holotype and allotype in California Academy of Sciences, paratypes in U. S. National Museum, Academy of Natural Sciences at Philadelphia, and the collections of J. Bequaert, E. G. Linsley, P. H. Timberlake, and the author.

The combination of notched clypeus, coarse puncturation of abdominal tergites three and four, and thirteen segmented male antennae easily distinguish this species. At present it is known only from Texas. The species is named for the collector of the holotype and allotype, E. G. Linsley, who has donated many other specimens treated in this paper.

Pterocheilus crispocornis Bohart, new species

(Pl. I, fig. 27; Pl. II, fig. 15)

Male.—Bright yellow; ventral spots on antennal segments eight to ten, antennal segments eleven to thirteen mostly, front mostly, post-ocular area mostly, vertex, irregular mark on mesopleuron, mesonotum except for two reddish spots, median propodeal line, longitudinal spot at base of first abdominal tergite, transverse triangular spot on base of second, basal bands on following tergites and fifth to seventh sternites,

genitalia, black; antenna except at base and apex, labial palpus, irregular marks on side of prothorax and mesopleuron, a spot on either side of mesonotum, scutellum and propodeum anteriorly, femora for the most part, insides of tibiae and tarsi, irregular marks posteriorly bordering the black areas of tergites one and two, basal marks on sternites two and three, brownish red; wings lightly stained with brown, veins reddish brown and black. Pubescence inconspicuous and pale, that on front and propodeum hardly two ocellus lengths, clypeus and abdominal tergites with fine appressed pubescence only, that on mesonotum hardly one ocellus length; outer sides of tibiae with four to eight short reddish bristles in addition to pubescence. Clypeus hardly punctured, punctures of front separated by one and a half puncture diameters on the average, those on vertex by three or four puncture diameters, those on pronotum and mesonotum by about two puncture diameters, punctured areas of abdominal tergites restricted to apical bands, punctures of second tergite separated by about two and a half puncture diameters, those of fifth tergite separated by about five puncture diameters. Clypeus roughly heptagonal, lateral and latero-apical sides of equal length, apex truncate and hardly as long as fifth antennal segment, mandible four-toothed, last segment of labial palpus three-quarters as long as second, antenna rolled apically, last two segments of antenna flattened dorso-ventrally and somewhat longer than broad, middle femur strongly contorted by means of deep baso-ventral and antero-apical depressions, lateral angles of propodeum rounded, second tergite as viewed from above about one and a third times as broad as long, second and third tergites with weak sub-apical transverse depressions; length to apex of second tergite 11 mm.

Female.—Markings, pubescence, and puncturation as in male with following exceptions: Vertex largely reddish, post-ocular area yellow, reddish marks on mesonotum contiguous, pronotum, scutellum, post-scutellum, and propodeum without reddish marks, second sternite black at base instead of reddish; wings violaceous apically, tibiae with twenty to thirty short reddish bristles in addition to pubescence, pubescence of vertex more fulvous than in male. Clypeus sparsely punctured, almost glabrous, shining, narrowly truncate apically, the truncation somewhat longer than fourth antennal segment. Length to apex of second tergite 13.5 mm.

Holotype male, Inyo Mts., Inyo Co., Calif., May 23, 1937; allotype female, Inyo Mts., Inyo Co., Calif., May 25, 1937; one paratype female, Mountain Springs Canyon, Argus Mts., Inyo Co., Calif., 5,000 ft. elev., May 22, 1937; one female, Palms to Pines Highway, Riverside Co., Calif., April 18, 1937; one male paratype, Imperial Co., Calif., June, 1912 (J. C. Bridwell). Holotype and allotype in California Academy of Sciences, paratypes in U. S. National Museum and collection of author. This species is intermediate between *linsleyi* and *denticulatus* in male characters. The first has hardly deformed middle femora and the last antennal segment is long and

slender; *crispocornis* has markedly deformed middle femora and the last antennal segment is short and thin; whereas *denticulatus* has extraordinarily deformed middle femora together with abnormal hind legs, and the last antennal segment is short and thick. The female of *crispocornis* can be separated from *linsleyi* by the latter's notched clypeus and from *denticulatus* by its heavier puncturation.

Pterocheilus denticulatus (Saussure)

(Pl. I, figs. 17, 28, 30; Pl. II, fig. 16)

Leptochilus denticulatus Saussure, 1855, Rev. and Mag. Zool., 7: 373.
Pterochilus lewisii Cresson, 1868. Trans. Amer. Ent. Soc., 1: 382 (female type A. N. S. P.)
Pterochilus aztecus Saussure, 1871. Rev. and Mag. Zool., 22: 141.
Odynerus (*Antepiponus*) *denticulatus* Saussure, 1875. Smithson. Misc. Coll., 254: 362, Pl. IV, figs. 30, 30a.

Male.—Black; mandible, clypeus except apically, last antennal segment, postocular line, prothorax mostly, postscutellum, apical bands on all abdominal tergites and sternites three to five, broken on four and five, yellow; first two antennal segments, mesopleural spot, spots on scutellum, legs mostly, lateral spots on tergites one and two, reddish; wings brown-stained, with dark tips. Clypeus with upper half weakly silvered, pubescence of front and propodeum two to three ocellus lengths, that of mesonotum and first abdominal tergite one to two ocellus lengths, that of remaining tergites less than one ocellus length. Body covered with moderate-sized almost contiguous punctures, more sparse on venter, obsolete on basal three-fourths of clypeus. Antenna thirteen segmented, terminal segment cup-shaped and about twice as large as twelfth; clypeus roughly seven-sided, apex nearly straight and about half as long as seventh antennal segment; propodeum rounded laterally; middle femur with a deep channel on its inner side, middle tibia dentiform apically, hind femur depressed beneath basally, hind tibia flattened on its outer side and greatly expanded apically; genitalia very peculiar (see figure); length to apex of second tergite 13 mm.

Female.—Coloration, pubescence, and puncturation about as in male with following exceptions: Pale markings of head and thorax all reddish, clypeus entirely reddish, propodeum with a large reddish spot laterally. Clypeus strongly punctured throughout. Apex of clypeus nearly straight and as long as sixth antennal segment; middle femur slightly irregular; length to apex of second tergite 15 to 16 mm.

Records.—One female, New Mexico (*lewisii* type); one male and one female, southern Arizona; one male, Nogales, Arizona, August 20, 1933; one male, Palmerlee, Arizona; one male, Rio Mayo, Sonora, Mexico; one male, Coscomotepec, Mexico (H. Saussure, *denticulatus* type).

This species is at once separated from all others by the extraordinary structure of the male middle femora which are

so deeply and sharply channeled that they look as if eaten by museum pests. The female has the clypeus truncate apically and can be differentiated from *mexicanus* by the latter's blackish wings; from *texanus* by the latter's smaller size, reddish flagellum and much more weakly punctured clypeus; and from other related species by the close coarse puncturation of the second abdominal tergite. It occurs in Mexico and southwestern United States.

Pterocheilus mexicanus Saussure

Pterochilus mexicanus Saussure, 1870. Rev. and Mag. Zool., 22: 141

Female.—Largely dark reddish; flagellum mostly, sutures of thorax, thoracic pleura below and thoracic sterna mostly, venter partly, wing veins, black; apical margins of abdominal tergites one to four, dull yellow; wings dark brown, violaceous. Borders of clypeus covered with appressed fulvous hair; pubescence of front and propodeum from one to two ocellus lengths, that of mesonotum and first abdominal tergite thick but less than one ocellus length. Clypeus closely punctured throughout, rest of body closely and moderately coarsely punctured except for smooth thoracic pleural areas and areas of venter. Apex of clypeus slightly concave, as long as fourth antennal segment; length to apex of second tergite 16.5 mm.

Records.—One female, Valley of Mexico (on a high plateau), (H. Saussure, type); one female, San Bernardo, Sonora, Mexico, October 9, 1935 (H. Gentry).

A single female in my collection answers Saussure's description of this species. It is a larger, darker species than *denticulatus* and has nearly black, violaceous wings. The redescription is based on my specimen.

Pterocheilus nigricaudus Bohart, new species

Female.—Black; basal half of antenna, mandible, labial palpus, orbit below emargination, inter-antennal spot, large post-ocular spot, prothorax, two mesopleural spots, tegula, scutellum, postscutellum, propodeum save for a median stripe, legs except at base of coxae beneath, first and second abdominal segments except for a triangular centro-basal spot on tergites one and two, apical margins of third to sixth sternites obscurely, deep orange; wings stained with brownish, particularly along the front margins. Pubescence except for the normally long-haired mouthparts, weak, pale, and sparse; that below ocelli and on angles of propodeum hardly two ocellus lengths; abdomen almost glabrous except for short, sparse, black bristles on tergites three to six; outer sides of tibiae with twenty to forty short bristles in addition to pubescence. Puncturation of head and thorax weak and sparse, punctures on vertex separated by about four and on pronotum by about three puncture diameters, puncturation of abdomen almost obsolete. Mandible stout

and five-toothed, clypeus slightly transversely strigose, apical truncation of clypeus about as long as fifth antennal segment; prothoracic angles rounded, not prominent, lateral angles of propodeum rounded; second tergite once and a half as broad as long viewed from above; length to apex of second tergite 11 mm.

Holotype female, Owens Valley, Inyo Co., Calif., May 24, 1937 (L. R. Gillogly). Holotype in California Academy of Sciences.

The peculiar markings of this species separate it at once from all other described species except *sibericus* Morawitz. The latter, however, is densely punctured on the head and thorax in contrast to *nigricaudus*. Although the male is unknown, this species must fall into *Megapterocheilus* by virtue of its large size, narrow clypeal truncation, bristly tibiae, and five-toothed mandibles.

Pterocheilus oregonensis Bohart, new species

Female.—Black; basal spot on clypeus, prothorax above, mesopleural spot, tegula mostly, two large spots on scutellum, postscutellum, large spot on lateral angle of propodeum, apical bands on tergites one to five, that on first tergite continued toward base, second tergite with nearly free lateral spots, fifth tergite entirely except for a black spot on either side, large basal spot on sixth tergite, irregular apical bands on sternites two and four, yellow; apical spot on clypeus, basal two antennal segments in front, mandible except at base, labial palpus, postocular stripe, femora mostly, tibiae and tarsi entirely, brownish red; wings tinted with brown especially along front margins, veins dark brown. Pubescence pale and inconspicuous, hardly two ocellus lengths beneath ocelli and one ocellus length or less on mesonotum, abdomen with minute appressed pubescence, outer sides of tibiae with thirty to forty short reddish bristles in addition to pubescence. Head and thorax for the most part moderately punctured; vertex and propodeum weakly and sparsely punctured, mesopleuron with large but well separated punctures, abdominal segments with well segregated apical punctured areas, the punctures small and separated by an average of about four puncture diameters. Clypeus with an apical notch forming an angle of about 100 degrees, the notch terminating on either side in a sharp point; lateral angles of propodeum rounded; second abdominal tergite as viewed from above almost square, slightly broader than long, length to apex of second tergite 9 mm.

Holotype female, Lakeview, Oregon, July 24, 1930, 4,800 ft. elev. (H. A. Scullen). Holotype in California Academy of Sciences.

This species can be recognized by its notched clypeus, relatively small size, and black and yellow markings. It is the first species with notched clypeus to be recorded from

Oregon. Of the related species, all of which are larger, *quinquefasciatus* reaches the far west only in the drier parts of eastern Washington and Oregon, *pedicellatus* is a southwestern Great Basin form, and *linsleyi* has been recorded only from Texas. Also, the entirely different markings of these three species distinguish them at once from *oregonensis*.

Pterocheilus trichogaster Bohart, new species

(Pl. I, fig. 12)

Male.—Black; clypeus, mandible, labial palpus, first antennal segment in front, an elongate post-ocular spot, front margin of prothorax, two mesopleural spots, two spots on scutellum, postscutellum, angles of propodeum, femora except basally, tarsi except apically, abdominal sternites except basally, apical bands on abdominal tergites, second tergite except for a central X-shaped black mark, pale yellow; wings brown-stained except toward front margins. Body covered with tawny pubescence, labial palpi covered with long sparse hairs, that between ocelli and antennal bases almost as long as third antennal segment, slightly shorter on thorax and sparse, first abdominal tergite and base of second sparsely covered with erect hair about as long as fourth antennal segment, pubescence on third and following abdominal segments very short and almost invisible. Clypeus evenly punctured throughout; dorsum of abdomen dull, closely and finely punctured. Antenna thirteen segmented, the last segment longer than broad and apically pointed; third segment of labial palpus two-thirds as long as second; mandibles with only three distinct teeth; clypeus heptagonal, the apical sides longest, apex slightly concave; lateral angles of propodeum rounded; middle femur without a basal depression; length to apex of second tergite 10 mm.

Female.—Coloration, pubescence, and puncturation about as in male with following exceptions: Yellow of a deeper shade, basal segment of labial palpus with its outer side black. Outer side of tibiae each with from thirty to forty short reddish bristles in four or five rows in addition to pubescence. Apical truncation of clypeus about equal to length of fourth antennal segment, length to apex of second tergite 11 mm.

Holotype male and allotype female, Mt. Diablo, Contra Costa Co., Calif., May 8, 1938 (G. E. and R. M. Bohart). Forty-five female and thirty-seven male paratypes from the following localities in California: Siskiyou Co. (F. W. Nunemacher); Yorkville and Hopland, Mendocino Co. (E. P. Van Duzee); Blue Lakes, Lake Co. (E. P. Van Duzee); El Portal and Indian Flat, Mariposa Co. (R. M. Bohart); Mt. Diablo, Contra Costa Co. (C. D. Michener, G. E. and R. M. Bohart); Mt. Hamilton, Santa Clara Co. (R. M. Bohart); Santa Lucia ts.M (C. D. Michener), and Bryson, Monterey

Co.; Potwisha, Tulare Co. (E. C. Van Dyke); Atascadero, San Luis Obispo Co. (E. P. Van Duzee); San Gabriel Mts., Los Angeles Co. (C. D. Michener); Deep Creek, San Bernardino Co. (E. G. Linsley); Mt. San Jacinto, Riverside Co., on *Penstemon*) (E. S. Ross).

Holotype and allotype in California Academy of Sciences, paratypes in collections of University of Kansas, U. S. National Museum, J. Bequaert, E. G. Linsley, C. D. Michener, and the author.

Although most closely related to *decorus* which also has unhooked thirteen segmented antennae in the male, *trichogaster* is very distinct. The long pubescence of the first abdominal tergite and the absence in the male of the pits on the second tergite easily distinguish it from *decorus*.

The species apparently prefers wooded mountainous areas of moderate to low elevation and with this restriction is found from San Bernardino County north to Oregon. A single male specimen at Pomona College has the data, "Catalina Island" (C. F. Baker).

Pterocheilus decorus Cresson

(Pl. I, fig. 13)

Pterochilus decorus Cresson, 1879. Trans. Amer. Ent. Soc. Proc., 7:18 (female holotype, A. N. S. P.).

Pterochilus zonatus Cresson, 1879. Trans. Amer. Ent. Soc. Proc., 7: 18 (male holotype, A. N. S. P.).

Odynerus (*Pachodynerus*) *cosmiogaster* Cameron, 1903. Invertebrata Pacifica, 1: 123 (male holotype?, Pomona College).

Pterochilus leucotaenius Rohwer, 1911. Proc. U. S. Nat. Mus., 40: 554 (female holotype, U. S. N. M.).

Black, marked with yellow or whitish; usually with a single mesopleural spot, scutellum usually unspotted in male; front coxa, at least, entirely dark; lateral spot of second tergite usually small, often unattached or absent; male last tergite unspotted. Pubescence longest on front where it is about two ocellus lengths; that of abdomen minute; male clypeus weakly silvered. Puncturation moderate; punctures contiguous on vertex and mesonotum, small and well separated on abdomen. Clypeus of male almost a heptagon with lateral sides the longest and apex slightly concave; apex of female clypeus nearly straight and slightly longer than fourth antennal segment; last four segments of male antenna striped beneath with black and yellow or fulvous; thirteenth antennal segment flattened dorso-ventrally, broadly rounded apically, and hardly flatter at the base than the twelfth segment at apex; lateral angle of propodeum rounded. Male middle femur expanded basally and flattened baso-ventrally. Male second abdominal tergite with a distinct spiracle-like lateral depression. Length to apex of second tergite, male 10 to 11 mm., female 12 to 13 mm.

Records.—Females, Lethbridge, Canada (*leucotaenius* types); one female, Bozeman, Montana, August 13, 1931 (J. Nottingham); one male, Grand Teton National Park, Wyoming, July, 1937 (J. McSwain); one male, Umatilla Co., Oregon, June 24, 1882; one male (*zonatus* holotype) and one female (*decorus* holotype), Nevada; one female, Grand Canyon, Arizona, June (S. P. Englehardt). Specimens in the author's collection are from the following counties in California, taken from May to July: Modoc, Trinity, Inyo, Mariposa, Madera, Los Angeles, San Bernardino, and Riverside. P. H. Timberlake has collected the female on *Trifolium variegatum* and E. S. Ross and E. G. Linsley have collected the male on *Penstemon* and *Eriodictyon*.

Although the antennae of the type specimen of *zonatus* are deformed, there can be little doubt that it is the male of *decorus*. The female *decorus* is difficult to distinguish from small specimens of *mirandus*, but the former is considerably darker and has a spot of reddish pubescence on either side of the second tergite. The male *decorus* is easily identified by the combination of its thirteen-segmented antennae with the last segment flattened, and the prominent spiracle-like depressions of the second tergite. The pale coloration varies from yellow to whitish and both forms apparently occur in a single locality. The species ranges over most of North America from the Rocky Mountains westward.

Pterocheilus texanus Cresson

(Pl. I, fig. 14)

Pterochilus texanus Cresson, 1872. Trans. Amer. Ent. Soc., 4: 244 (female holotype, A. N. S. P.).

Male.—Black; spot on mandible, clypeus, first antennal segment in front, inter-antennal spot, lower orbit, post-ocular line, prothorax above except posteriorly, mesopleural spot, two spots on scutellum, postscutellum, spots on coxae and tibiae, irregular apical bands on all abdominal tergites and second to fifth sternites, yellow; mandible apically, flagellum except apically, tegula, lateral spot on propodeum, legs mostly, latero-basal spots on first and second abdominal tergites, reddish; wings yellow stained. Clypeus silvered weakly, pubescence of front and propodeum not more than two ocellus lengths, that of mesonotum about one ocellus length, that of abdomen moderately thick on first two tergites and semi-erect but less than one ocellus length. Clypeus thickly but minutely punctured, puncturation of dorsum moderate with almost contiguous punctures, those of propodeum and last few abdominal tergites more separated. Clypeus approximately six-sided with irregularly curved base and with apex shorter than fourth antennal segment,

apex almost straight, lateral and latero-apical sides about equal; antenna thirteen segmented, last segment rounded apically and very flat, twelfth segment not flattened and slightly longer than thirteenth; propodeum rounded laterally; middle femur somewhat expanded basally and with a baso-ventral flat area; length to apex of second tergite 10 mm.

Female.—Coloration, pubescence, and puncturation about as in male with following exceptions: Markings of head, thorax, and sometimes abdomen dull reddish, venter dark brown. Clypeus narrowly truncate and slightly produced apically, truncation as long as fifth antennal segment; length to apex of second tergite 11 to 12 mm.

Records.—Males and females, Texas (Belfrage types); one male, Lee Co., Texas, April, 1907; two males, Fedor, Texas, April, 1907; one male, Fedor, Texas, April 13, 1898 (Birkmann); one female, Southern Pines, North Carolina, May 23, 1908, (A. H. Manee).

This species is characterized in the male by the small apically rounded thirteenth antennal segment which is much flatter than that of *decorus* and much larger than that of *inyoensis*. *P. texanus* differs further from *inyoensis* by the much heavier puncturation of the second abdominal tergite in the former. The species is at present known only from Texas and a single record from North Carolina. The above was a redescription of the female and an original description of the male.

Pterocheilus inyoensis Bohart, new species

(Pl. I, fig. 15)

Male.—Black; clypeus, mandible for the most part, first two antennal segments in front, a frontal spot, a post-ocular stripe, pronotum except at sides, mesopleural spot, very small spot on either side of scutellum, postscutellum, a double spot on either side of propodeum, legs in front mostly, apical bands on abdominal segments, that of second tergite broadly U-shaped, those of remaining tergites and all sternites except the last depressed on either side of the middle, last tergite with central spot only, last sternite except for central black spot, yellow; basal three-fifths of antenna, labial palpus, hind coxa, middle and hind femora behind, large medio-lateral spot on first tergite, sub-basal lateral spot on second tergite, first sternite mostly, second sternite except for apical yellow band, brownish-red; wings brownish-red stained along the margins, veins partly reddish and partly black. Pale pubescence on front and angles of propodeum hardly three ocellus lengths, on mesonotum about one ocellus length, minute on abdomen and appressed, clypeus with appressed pubescence only; outer sides of tibiae with fifteen to twenty short bristles in addition to pubescence. Puncturation of head and thorax weak, clypeus weakly and sparsely punctured, punctures on vertex about three and on prothorax about one and a half puncture diameters apart, propodeum very weakly punctured and shining, apical margins of abdominal segments obscurely and sparsely punctured.

Antenna only slightly curved, twelfth segment slightly shorter than eleventh, thirteenth segment very small round and flat; mandibles distinctly four-toothed, last segment of labial palpus half as long as second and one-quarter as long as first segment; clypeus longer than broad, heptagonal, latero-apical sides longest, apical side as long as sixth antennal segment; middle femur somewhat flattened at base but not excavated or contorted; lateral angles of propodeum rounded, second abdominal tergite as seen from above about one and two-thirds as broad as long; length to apex of second tergite 9 mm.

Holotype male, Lone Pine, Inyo Co., Calif., May 19, 1937 (E. C. Van Dyke); one paratype male, Olancha, Inyo, Co., Calif., May 20, 1937 (C. D. Michener), one paratype male, Essex, San Bernardino Co., Calif., May 29, 1937 (M. A. Cazier). Holotype in California Academy of Sciences, paratypes in collection of author.

The unique antennae, sparse puncturation, and simple middle femora will serve to distinguish the male of this species from all others of the subgenus. The thirteen segmented antennae with a minute terminal segment is especially characteristic and illustrates a nice transitional stage between *decorus* and *mirandus*. The female is unknown but should be recognized from the abdominal markings and sparse puncturation.

Pterocheilus quinquefasciatus Say

(Pl. I, fig. 9)

Pterochilus quinquefasciatus Say, 1824. Keating's Narrat. Exped. App., 2:347.
Rhygchium quinquefasciatum Say, 1837. Bost. Jour. Nat. Hist., 1: 384.

Black, marked with whitish yellow and red. Mandibles, female clypeus, antenna partly, prothorax mostly, angles of propodeum, legs, baso-lateral spots on first and second abdominal tergites, red, male clypeus, prothorax partly, mesopleural spot, two spots on scutellum, postscutellum, and apical margins of all except terminal abdominal tergite, whitish yellow; last half of male antennal segment twelve, venter except for reddish markings on first two tergites, black. Pubescence very inconspicuous, that of front and propodeum not more than two ocellus lengths, shorter elsewhere; male clypeus weakly silvered; abdomen with minute pubescence only. Head and thorax covered with small but close-set punctures, becoming obsolete on the sides of thorax; abdomen with very fine punctures which gradually become thicker towards apices of segments. Female clypeus incised apically, the incision angular and slightly obtuse; propodeal angles rounded; male structural characters: Antenna twelve segmented, last segment slightly recurved, pointed, and as long as eleventh; clypeus hexagonal save for sharply angular apical incision, lateral sides the longest; basal half of middle femur strongly swollen. Length to apex of second tergite: male 10–14 mm., female 13–16 mm.

Records.—British Columbia (Vernon), Alberta (Manyberries), Washington (Wawawai and Connell), Oregon (Umatilla Co.), Montana, Idaho, Wyoming, South Dakota, Nebraska (Wauneta), New Mexico (Roswell), Oklahoma, Texas (Austin, Fedor, and Amarillo). June and July are the favored months of flight.

P. quinquefasciatus can be separated from other species in which the clypeus is angularly notched apically by the fine puncturation of the third abdominal tergite and the unrestricted punctured area of the second tergite. The species belongs in the group having the male antennae twelve-segmented and is closely related to *pedicellatus* with which it is often confused in collections. The latter, however, is lighter in color, has the punctured area of the second tergite restricted, and the last antennal segment in the male is strongly constricted basally. The range of *quinquefasciatus* extends from Texas through the Great Plains and Rocky Mt. region into Canada and also in eastern Washington and Oregon.

Pterocheilus pedicellatus Bohart, new species

(Pl. I, fig. 10)

Male.—Black; clypeus, first antennal segment in front, interantennal spot, a central stripe on mandible, border of compound eye below emargination, postocular stripe, prothorax dorsally, mesopleural spot, tegula, two spots on scutellum, spot on propodeal angle, middle coxa mostly, femora apically, tibiae externally, broad apical bands on all abdominal segments except first and last sternites, second tergite almost entirely, deep yellow; antenna beneath and apically except for tip of last segment, inner margin of mandible, labial palpus, propodeum for the most part, front and hind coxae, femora mostly, tibiae internally, tarsi mostly, first and second tergites at the base except for central black marks, first sternite entirely, second at base, dull reddish; wings stained with reddish along the front margin and brownish at the tips. Pubescence pale, sparse, less than the length of an ocellus except on vertex and propodeum where it hardly exceeds three ocellus lengths; that on abdomen very fine, appressed; outer sides of tibiae with a few stout reddish bristles in addition to pubescence. Clypeus sparsely and weakly punctured, vertex and thorax except for sides of propodeum moderately punctured; abdominal segments with discrete punctured areas along the apical margins, the punctures well separated. Antenna twelve-segmented, curled slightly at the apex, terminal segment strongly pedicellate at the base forming a rough triangle; clypeus approximately eight-sided, two sides being formed by an angular apical emargination, longest side bordering compound eye; mandible with four distinct teeth; head oval, broader than long; middle femur strongly swollen basally, constricted apically; lateral angles of propodeum rounded; length to apex of second tergite 11 mm.

Female.—Coloration, pubescence, and puncturation approximately as in male with following exceptions: Mandible except for black teeth, antenna basally, clypeus, large post-ocular spot, prothorax, legs entirely, reddish (mesonotum mostly red in some paratypes); wings more heavily stained with brownish red. Outer sides of tibiae each with twenty-five to thirty-five short reddish bristles in addition to pubescence; length to apex of second tergite 12 mm.

Holotype male and allotype female, 25 miles east of Sonorita, Ariz., Aug. 9, 1924 (J. O. Martin). Paratypes, one female Peppersauce Canyon, Santa Catalina Mts., Ariz., Aug. 15, 1924 (E. P. Van Duzee); one male, "Rinconada," Sept. 26, on *Bigelovia;* one female, Las Cruces, N. M.; one male, Magdalena, N. M., Aug. 28, 1917, on flowers of *Asclepias galioides* (A. K. Fisher); one male and two females, Albuquerque, N. M., June 27, 1931, 5000 ft. elev. (H. A. Scullen); one female, Pecos, N. M., June 24, (W. P. Cockerell); one male, Salt Lake City, Utah, June 25, 1922 (E. P. Van Duzee); one female, Meadow Valley, Mexico (Townsend). Holotype and allotype in California Academy of Sciences, paratypes in U. S. National Museum, collection of J. Bequaert, and collection of the author.

This species resembles *quinquefasciatus* Say and in most collections is confused with it. However, the strongly pedicellate last antennal segment in the male and the restricted puncturation of the second tergite in both sexes of *pedicellatus* are diagnostic. On the other hand, the peculiar middle femur in the male and the apically incised clypeus are very similar in the two species. Utah, Arizona, New Mexico, and northern Mexico constitute the known range of *pedicellatus*.

Pterocheilus biplagiatus Cresson

(Pl. I, fig. 11)

Pterochilus biplagiatus Cresson, 1879. Trans. Amer. Ent. Soc. Proc., 7: 19 (female holotype, A. N. S. P.).

Black, marked with yellow. Clypeus with two black spots in female, male antenna except for apex of last segment fulvous beneath, male scutellum unspotted, venter black in female and weakly yellow-banded in male, second tergite with an angular usually detached lateral spot. Clypeus almost bare in female, very weakly silvered in male, hair on front four ocellus lengths or more, that of mesonotum somewhat shorter, that of first abdominal tergite semi-erect and two to three ocellus lengths. Head and thorax finely and closely punctured, abdomen with small well separated punctures on apices of segments. Apex of female clypeus truncate, the truncation slightly longer than fourth antennal segment; male clypeus almost a heptagon, apico-lateral sides the longest; male antenna twelve segmented, last segment truncate apically and

similar in size and shape to the eleventh; propodeum rounded laterally; male middle femur expanded at base and with a long narrow baso-ventral shallow groove. Length to apex of second tergite: Male 8 to 10 mm., female 9–11 mm.

Records.—One female, Blue Mts., Washington, June 27, 1922 (V. N. Argo). California: Fourteen males and eleven females, Antioch, Contra Costa Co., May, 1938, at flowers of *Phacelia* (G. E. and R. M. Bohart); one female, Panoche Hills, Merced Co., April 29, 1922 (E. C. Van Dyke); two females, Coalinga, Fresno Co., May, 1938 (M. A. Cazier); two males, Claremont, Los Angeles Co. (C. F. Baker); one female, Poway, San Diego Co., May 30, 1884 (F. E. Blaisdell).

The type series at the Academy of Natural Sciences in Philadelphia bear the label "Cala," presumably referring to California. However, the allotype and one paratype male are *trichogaster* rather than *biplagiatus* and an unidentified "Cala" specimen is the true male. *P. biplagiatus* can be recognized in the male by its twelve segmented antennae, haired first abdominal tergite, and the spiracle-like depressions of the second tergite. The female has the first tergite haired but the clypeus is almost bare. So far as known the species is confined to the Pacific Slope.

Pterocheilus mirandus Cresson

(Pl. I, figs. 3, 4, 26; Pl. II, fig. 3)

Pterochilus mirandus Cresson, 1879. Trans. Amer. Ent. Soc. Proc., 7: 17 (types, A. N. S. P.).

Pterochilus luteicollis Cameron, 1909. Pomona Jour. Ent., 1: 84.

Black with extensive yellow markings; clypeus entirely yellow, mesopleuron with two large spots below tegula, scutellum with two large spots, propodeum yellow except for central black stripe, abdomen almost entirely yellow, second tergite with a central X-shaped black mark, last tergite yellow-spotted in both sexes, underside of flagellum in male orange except for apical half of last segment. Pubescence on front and propodeum less than two ocellus lengths and that on rest of body less than one ocellus length; male clypeus weakly silvered; abdomen with minute pubescence only. Head and thorax moderately punctured; occiput and sides of thorax tending to become shiny; abdomen sparsely and minutely punctured. Male clypeus approximately six-sided, the base irregularly curved, apex straight and shorter than fourth antennal segment; male antenna twelve segmented, last segment slightly recurved, pointed, and as long as previous segment; male middle femur expanded at base and ventrally grooved; apex of female clypeus very slightly concave, as long as fourth antennal segment. Length to apex of second tergite: Male 11–14 mm., female 15–17 mm.

Records.—Nevada (types, A. N. S. P.). California: The following counties are represented in my collection: Inyo, Sacramento, Yolo, Contra Costa, Mariposa, Fresno, Tulare, Kern, Los Angeles, Riverside, and Imperial. The flight period is from May to October with the probability of two broods. P. H. Timberlake has collected both sexes in Riverside County in October on *Trichostema lanceolatum* and I have taken the female in Los Angeles County in May on *Phacelia grandiflora.*

This species is characterized in the male by the twelve segmented antennae, truncate clypeus, and hairless first abdominal tergite. The female is difficult to distinguish from *decorus* although the latter is smaller and darker. *P. mirandus* ranks in size with *quinquefasciatus* and *pedicellatus.* The black and yellow pattern with yellow predominating should be sufficient to separate the species in most cases.

Onchopterocheilus Bohart, new subgenus

(Type, *Pterochilus comptus* Cresson)

Medium to small *Pterocheilus.* Male antenna hooked apically, the last two segments greatly reduced. Labial palpus three segmented, the last two segments in the female strongly flattened and thickly haired. Maxillary palpus six segmented. Female mandibles stout and distinctly five toothed. Female clypeus usually rounded or pointed apically, when truncate, the truncation is more than half the length of the scape.

Only North American species are included in this subgenus because I have not seen any of the exotic species, such as *linguarius* Saunders from Algeria, in which the male antennae are apically hooked. *Onchopterocheilus* bears to *Megapterocheilus* much the same relationship in regard to male antennae that *Rygchium* bears to *Odynerus* sensu stricto (=*Hoplomerus*). In fact, the parallelism in antennae goes even farther because certain species, such as *laticeps,* have the last two segments reduced so as to approximate the condition found in *Pachodynerus.*

Pterocheilus laticeps Cresson

Pterochilus laticeps Cresson, 1872. Tr. Am. Ent. Soc., 4: 244 (type A. N. S. P.)

Black, marked with whitish, the black often partially supplanted by reddish on mandibles, clypeus, scutellum, and first two abdominal segments; female clypeus with whitish lateral spots and black or reddish central stripe; legs black, white, and red; hairs of labial palpus whitish; wings almost clear except marginally. Pubescence of entire body silvery, that of clypeus dense and appressed, that of front about two

ocellus lengths, that of propodeum hardly one ocellus length, elsewhere minute. Puncturation moderate, the punctures well spaced, often fine towards bases of abdominal segments. Apical two segments of male antenna together distinctly shorter than eleventh and usually partially retracted within it. Male clypeus nearly a heptagon, apex somewhat convex; female clypeus obtusely pointed apically; length to apex of second tergite, male 7–8 mm., female 9–10 mm.

Records.—Texas: One female, "Tex." (Cresson type); two females, "Texas" (Belfrage); Arizona: One female, Tucson, Aug. 29 (F. M. Carpenter); two males and one female, 18 miles south of Tucson, July 31 and Aug. 1, 1924 (E. P. Van Duzee). California: one male, Palm Springs, April 16, 1938 (G. E. and R. M. Bohart; nine males and four females, Lone Pine, Inyo Co., May and June; one male, Independence, Inyo Co., June 1, 1937 (C. D. Michener); one female, Darwin Falls, Inyo Co., May 30, 1937.

The comparison of a series of specimens from Arizona and California with the type specimens and other Texan material leads me to the conclusion that only a single species is involved. Variation in any one region argues against the advisability of erecting subspecies. However, the variation in color and puncturation as well as in the hook of the male antenna are striking when only a few specimens are examined. The basic color scheme is black and whitish but more or less extensive reddish markings may supplant the black on the clypeus, scutellum, and first two abdominal segments. The last two segments of the male antenna are typically minute and partially enclosed in the eleventh. This character and the red and white marked legs will distinguish the species from others of the subgenus.

Pterocheilus panamintensis Bohart, new species

Male.—Black; clypeus save for a triangular apical mark, stripe along lower orbit, post-ocular stripe, front margin of prothorax, mesopleural spot, spots on tegula, two spots on scutellum, postscutellum, small spot on lateral angle of propodeum, coxae mostly, tibiae and tarsi partly, simple apical bands on tergites one to six and sternites two and three, whitish; second and following antennal segments beneath, femora partly, tibiae mostly, tarsi entirely brownish red; wings brown-stained, and violaceous apically. Clypeus moderately silvered, without appreciable erect hair; pubescence of front from two to three ocellus lengths, that of mesonotum and propodeum less than one ocellus length; pubescence of abdomen minute. Clypeus weakly punctured; front, dorsum of thorax, and abdomen closely punctured, second tergite with punctures separated by about one puncture diameter or less, moderately coarse. Clypeus octagonal, latero-apical sides slightly the longest, apex slightly

concave; last antennal segment pointed but not sharply, shorter than twelfth, last two segments together about two-thirds as long as eleventh; pronotal angles obtuse, lateral angles of propodeum rounded; middle femur not perfectly regular but without an evident basal depression; second tergite once and a half as broad as long viewed from above; length to apex of second tergite 8 mm.

Holotype male, Panamint Mts., Inyo Co., Calif., May 28, 1937 (C. D. Michener). Holotype in California Academy of Sciences.

The coloration and relatively large last two antennal segments in the male separate this species from all others in the subgenus. In general coloration it most nearly approaches *hirsutipennis* but the red markings of the legs and lack of erect hair on the first abdominal tergite readily separate it from that species. The abdominal markings are unusual for the subgenus, being simple apical bands on most of the tergites and a few of the sternites.

Pterocheilus trachysomus Bohart, new species

(Pl. I, fig. 29; Pl. II, fig. 11)

Male.—Black; labial palpus, mandible, clypeus, first antennal segment in front, inter-antennal spot, orbit below emargination, post-ocular stripe, pronotum above, two mesopleural spots, tegula, two triangular spots on scutellum, postscutellum, a large spot on lateral angle of propodeum, legs mostly, apical bands on first six abdominal segments, that on first tergite with a square anterior margin, that on second tergite having a roughly X-shaped black spot, that on second sternite with a V-shaped anterior margin and enclosing a pair of subapical black spots, yellow; second and following antennal segments, tarsi partly, brownish red; antenna above, wing veins mostly, brown; wings slightly brown-clouded especially along front margin. Clypeus moderately silvered and without erect hair, hair on front sparse and less than one ocellus length, abdomen with minute pubescence only. Clypeus well punctured toward apex; front, mesonotum, and entire second tergite with large punctures separated by less than a puncture diameter. Mandible five toothed, sub-basal tooth very small; labial palpus apparently two-segmented, basal segment twice as long as terminal; clypeus octagonal, lateral, latero-apical and apical sides the longest and about equal, apex slightly convex (strongly in some paratypes); last two segments of antenna minute, stout, and partially enclosed in eleventh segment; pronotal angles almost ninety degrees; lateral angle of propodeum rounded; middle femur slightly undulate beneath and with a basal angle or hump; first abdominal segment long and narrow, second tergite as viewed from above slightly broader than long; length to apex of second tergite 8 mm.

Female.—Markings, pubescence, and puncturation about as in male with following exceptions: Clypeus with a central spot running to the base, three mesopleural spots, two longitudinal stripes on mesonotum,

yellow; no black spots on second sternite. Clypeus angularly convex at apex, almost pointed; middle femur with a slight basal hump; length to apex of second tergite 10 mm.

Holotype male, Sentenac Canyon, San Diego Co., Calif., October 7, 1935, at flowers of *Eriogonum* (F. F. Thorne); allotype female, Riverside, Calif., October 10, 1932, on *Ericameria palmeri* (P. H. Timberlake); paratypes, California: One female, Riverside, Aug. 4, 1925 (P. H. Timberlake), two males and one female, Los Angeles Co.; six males, La Crescenta, Los Angeles Co., August, on *Eriogonum* (C. D. Michener and R. M. Bohart); one male, Mohave River, Los Angeles Co., August 14, 1936, on *Eriogonum* (P. H. Timberlake); one female, San Jacinto Mts., Riverside Co., June 17, 1939 (E. G. Linsley); two females, "So. Cal."; one female, Jacumba, San Diego Co., Aug. 12, 1917; Idaho: One female, Boise, July 31, 1934 (R. E. Miller).

Holotype and allotype in California Academy of Sciences, paratypes in U. S. National Museum, and collections of J. Bequaert, P. H. Timberlake, C. D. Michener, and the author.

The coarse puncturation particularly on the second abdominal tergite separates this species from the other black and yellow *Onchopterocheilus*. The knob at the base of the male middle femur varies in size to some extent, being most prominent in specimens from La Crescenta. The puncturation is also variable but the second tergite always has large approximate punctures at its middle. The species probably occurs over a considerable portion of western North America where it flies in the late summer and fall.

Pterocheilus timberlakei Bohart, new species

(Pl. II, fig. 10)

Male.—Black; clypeus, mandible, labial palpus, first two antennal segments in front, orbit below emargination, post-ocular stripe, prothorax above, two mesopleural spots, tegula, two spots on scutellum, postscutellum, large lateral spot on angle of propodeum, coxae and femora partly, tibiae and tarsi mostly, apical margins of all abdominal segments except last, that of second tergite squarely U-shaped in front, second sternite except for basal black margin, yellow; underside of third and following antennal segments, tarsi partly, pale orange; wings faintly brown-clouded, veins brownish-red to black. Clypeus with very short inconspicuous pubescence much less than one ocellus length, front and vertex with sparse erect fulvous hairs about three ocellus lengths, that of mesonotum and propodeum about two ocellus lengths, abdomen with minute pubescence only. Clypeus with distinct but well separated punctures toward apex, punctures of front and mesonotum moderately large and nearly contiguous, sides of propodeum below impunctured

and shining, punctured areas of abdomen not conspicuously segregated, those of apical margin of second tergite separated by about two puncture diameters. Mandible five-toothed, middle tooth notched at apex; labial palpus apparently two-segmented, terminal segment about three-fifths as long as basal; clypeus roughly heptagonal, the sides nearly equal, strongly humped above the middle; terminal segment of antenna flattened, pointed, and slightly longer than twelfth; twelfth and thirteenth segments together more than two-thirds as long as eleventh; pronotal angles sharp, about ninety degrees as viewed from above; propodeal angle with a distinct ridge or low carina running from metathoracic spiracle towards insertion of abdomen; middle femur with a pronounced basal ventral depression extending almost half its length; second tergite as viewed from above one and two-fifths as broad as long; length to apex of second tergite 5.5 mm.

Female.—Markings, pubescence, and puncturation about as in male with following exceptions: Apical black spot on clypeus, tarsi partially black, third and following tergites marked with whitish rather than yellow; pubescence of head and thorax somewhat shorter. Clypeus convexo-truncate apically; ridge of propodeum hardly carinate; length to apex of second tergite 8 mm.

Holotype male, allotype female, and two male paratypes, Taquitz Canyon, Palm Springs, Riverside Co., Calif., April 16, 1938 (G. E. and R. M. Bohart); other paratypes (all from California): One male and one female, Palm Springs, Riverside Co., March and April, at flowers of *Cryptantha* and *Sphaeralcea ambigua* (P. H. Timberlake); one female, San Diego Co., April (D. W. Coquillett); one male and one female, Little Rock, Los Angeles Co., April (G. E. and R. M. Bohart); one male, Morongo Valley, San Bernardino Co., April 22, 1937 (P. H. Timberlake); four males, Atascadero, San Luis Obispo Co., April 26, 1919 (E. P. Van Duzee); two males and five females, San Luis, Obispo Co., May; one male, Glenville, Kern Co., May 17, 1931 (P. H. Baldwin); one female, Santa Lucia Mts., Monterey Co., May 18, 1938 (C. D. Michener); one male, El Portal, Mariposa Co., May 23, 1938 (R. M. Bohart). Holotype and allotype in California Academy of Sciences, paratypes at U. S. National Museum, Academy of Natural Sciences at Philadelphia, and collections of J. Bequaert, P. H. Timberlake, C. D. Michener, and the author.

This species is the only North American *Pterocheilus* thus far described with a complete or nearly complete longitudinal ridge or carina along the propodeal angles. This ridge varies considerably in prominence, being in general more pronounced in specimens from the northern section of its range and sharpest in males. It is most closely related to *bakeri* in which there is

sometimes a faint indication of a ridge ending in an inconspicuous tubercle on the propodeal angles. In *bakeri*, however, the puncturation of the second abdominal tergite is much more coarse, the clypeus in the female is apically truncate instead of convex, and the male clypeus has moderately long semi-erect hair at the base and sides. Furthermore the male of *timberlakei* has a prominent basal ventral depression on the middle femur, further differentiating it from *bakeri* and *comptus*. The species is named for P. H. Timberlake, who collected a portion of the type series and many other specimens considered in this paper.

Pterocheilus micheneri Bohart, new species

Pl. I, figs. 5, 6, 22)

Male.—Black; clypeus, labial palpus, mandible, first two antennal segments in front, three small inter-antennal spots, orbit below emargination, post-ocular stripe, pronotum above, two mesopleural spots, tegula, two small spots on scutellum, postscutellum mostly, a large spot laterally on propodeal angle, coxae and femora partly, tibiae and tarsi entirely, apical bands on all abdominal segments except last, that on second tergite with a lateral extension towards the middle leaving a roughly X-shaped black mark, first and second sternites except at base, yellow; third and following antennal segments beneath pale orange; antenna above and wing veins brownish; wings slightly brown-stained. Clypeus weakly silvered, without erect hair; front with sparse pale pubescence about two ocellus lengths, that of mesonotum one ocellus length, that of propodeum less than two ocellus lengths; abdomen covered with minute appressed pubescence only. Clypeus indistinctly punctured; punctures of dorsum of head and thorax moderately large and mostly less than a puncture-diameter apart; punctures of apical margin of second abdominal tergite about a puncture diameter apart, those at center of second tergite very fine and separated by about three puncture diameters. Mandible five-toothed, middle tooth notched at apex; labial palpus apparently two-segmented, second segment seven-eighths as long as first; clypeus roughly octagonal, the sides about equal except for the smaller base, apex slightly convex; last antennal segment slightly longer than twelfth, sharply pointed, last two segments together almost as long as eleventh; pronotal angles obtuse, propodeal angles rounded, middle femur without a basal ventral depression; second abdominal tergite as viewed from above about one and a third as broad as long; length to apex of second tergite 8.5 mm.

Female.—Markings, pubescence, and puncturation about as in male with following exceptions: Clypeus with a small basal spot, two small inter-antennal spots, three mesopleural spots, large spots on scutellum, propodeum for most part, yellow. Pubescence of front and mesonotum shorter. Puncturation of second tergite finer. Clypeus shining, slightly silvered laterally, weakly punctured apically, apex angularly convex, almost pointed; length to apex of second tergite 10 mm.

Holotype male, Lone Pine, Inyo Co., Calif., June 12, 1937 (C. D. Michener); allotype female, Big Pine, Inyo Co., Calif., June 8, 1937 (E. C. Van Dyke); paratypes (all from California), seven males and one female, Lone Pine, Inyo Co., June; six males and one female, Big Pine, Inyo Co., June. One male metatype, Beaver Valley, Utah.

Holotype and allotype in California Academy of Sciences, paratypes in U. S. National Museum, and collections of J. Bequaert, P. H. Timberlake, C. D. Michener, and the author.

The extensive yellow markings, fine puncturation of the second tergite, apically convex clypeus, and reduced pubescence characterize this species. It belongs to the group in which the male has a simple middle femur, no erect hair on first abdominal tergite, and relatively large antennal hook. In addition to the characters given in the key it can be separated at a glance by its markings from *hirsutipennis*, *panamintensis*, and *pimorum*. The species is named for C. D. Michener who collected the holotype as well as many other *Pterocheilus* included in this paper.

Pterocheilus pimorum (Viereck)

(Pl. II, fig. 12)

Odynerus pimorum Viereck, 1908. Tr. Am. Ent. Soc., 33: 405 (type Univ. Kans.)

Male.—Yellow; vertex mostly, tip of last antennal segment, three longitudinal stripes on mesonotum, scutellum basally, bases of first two abdominal tergites, last segment partly, black; flagellum, tarsi partly, base of second tergite sometimes, reddish. Wings lightly stained except apically. Labial palpus nearly bare; pubescence of clypeus appressed, that of front about two ocellus lengths, that of mesonotum and propodeum about one ocellus length, that of abdomen minute. Puncturation scattered, irregular, the punctures well separated. Clypeus well silvered, longer than broad, approximately heptagonal; antenna relatively slender, all its segments distinctly longer than broad, last antennal segment oblong, flattened, reaching to base of eleventh; propodeum rounded laterally; middle femur normal; second abdominal tergite as long as broad seen from above; length to apex of second tergite 8–9 mm.

Female.—Markings, pubescence, and puncturation about as in male with following exceptions: Black markings except ocellar area and on first abdominal tergite replaced by reddish. Clypeus and mandible sparsely punctured, polished and shining. Pubescence of head and propodeum hardly one ocellus length, shorter on rest of body. Apex of clypeus nearly straight, two-fifths as long as apico-lateral side. Length to apex of second tergite 10–11.5 mm.

Records.—Arizona: Four males, Bill Williams Fork, August (F. H. Snow) (Viereck types). California: One male, Holtville,

Imperial Co., May 7, 1939, on *Cercidium torreyanum* (R. M. Bohart); one male, San Felipe Creek, Imperial Co., July 8, 1933 (H. S. Gentry); one female, Palm Springs, Riverside Co., July 20, 1934; one male, Coachella Valley; two females, Twenty-nine Palms, San Bernardino Co., Aug. 29, 1934, on *Wislizenia refracta* (C. D. Michener); one male and two females, 8 miles S. E. of Needles, San Bernardino Co., June 5, 1938, on *Dalea spinosa* (P. H. Timberlake); one male, Death Valley, Inyo Co., April 6, 1936 (H. Hultgren).

The almost entirely yellow markings of this species make it readily identified. Viereck described the species as an *Odynerus* from male specimens but an examination of the types showed them to be *Pterocheilus*. It appears to be intermediate between *bakeri*, with which it agrees in having a truncate clypeus in the female, and *micheneri*, but distinct from either. It is the only species I have seen in which the basal segment of the female labial palpus is entirely yellow.

Pterocheilus bakeri Cameron

(Pl. I, fig. 20, Pl. II, fig. 9)

Pterochilus bakeri Cameron, 1909. Pom. J. Ent., 1:123.

Male.—Black; clypeus, first antennal segment in front, two interantennal spots, lower orbit narrowly, post-ocular spot, prothorax above, tegula, spot below, two spots on scutellum, postscutellum above, legs partly, apical bands on first six abdominal segments, that on second tergite angularly but obtusely incised, yellow; antenna beneath, tarsi partly, reddish; wings stained with reddish. Labial palpus relatively long-haired; clypeus with semi-erect hair along the sides; pubescence of head hardly three ocellus lengths, that of mesonotum hardly two ocellus lengths; erect hair on first tergite two ocellus lengths or less. Puncturation coarse and moderately close, somewhat finer toward bases of abdominal segments. Clypeus roughly octagonal, apex sharply truncate; last two antennal segments flattened, together about two-thirds the length of segment eleven; middle femur without a basal depression; propodeum with dull lateral angles bearing a weak rough tubercle near the spiracle; length to apex of second tergite 8–9 mm.

Female.—Markings, pubescence, and puncturation about as in male with following exceptions: Clypeus usually with an irregular central black spot; propodeum laterally yellow. Clypeus sharply truncate apically; length to apex of second tergite 9–10 mm.

Records.—California: One female, Modoc Co., July (W. J. Chamberlin); one female, Madeline, Lassen Co., July 12, 1925; sixteen males, Indian Flat, Mariposa Co., May and June, 1938 (R. M. Bohart); one male, Potwisha, Sequoia National Park, Tulare Co., May 17, 1923 (E. C. Van Dyke); one female, Sheep

Creek, San Gabriel Mts., 5,000 ft., San Bernardino Co., June 3, on *Eriodictyon trichocalyx* (P. H. Timberlake); one male, Herkey Creek, San Jacinto Mts., Riverside Co., June 8, 1937 (P. H. Timberlake); three males, San Jacinto Mts., Riverside Co., June 17, 1939, on *Eriodictyon* (E. S. Ross); one female, Claremont, Los Angeles Co. (Baker), (Cameron type).

Characteristic of *bakeri* but not diagnostic is the irregular black spot in the center of the clypeus of the female. The only other species of the subgenus with a truncate clypeus in the female is *pimorum* and that can be recognized at once by its almost entirely yellow markings. The male indicates a relationship to *comptus* but can be separated by the characters given in the key. It occurs sparingly in many parts of California, principally in lower mountain ranges. The above is an original description of the male and a redescription of the female.

Pterocheilus comptus Cresson

(Pl. I, fig. 21, Pl. II, fig. 2)

Pterochilus comptus Cresson, 1879, Trans. Amer. Ent. Soc. Proc. 7:18 (female holotype, A. N. S. P.).

Male.—Black; mandible, clypeus, first antennal segment in front, lower orbit, inter-antennal spots, post-ocular stripe, pronotum above, two mesopleural spots, tegula mostly, two spots on scutellum, post-scutellum, propodeum laterally, legs mostly, apices of all abdominal segments, band of second tergite rounded anteriorly, yellow; flagellum beneath reddish; wings smoky, veins brown, apex of forewing dark. Clypeus unsilvered, its base sparsely covered with erect fulvous hair; pubescence of front three or more ocellus lengths, that of mesonotum and propodeum two to three ocellus lengths, that of first abdominal tergite one to two ocellus lengths, remainder of abdomen minutely pubescent. Clypeus weakly punctured, shining; dorsum of head and thorax closely punctured, weaker on propodeum; abdominal tergites fairly evenly punctured, the punctures small and separated by two or more puncture diameters. Clypeus roughly eight-sided, the five more apical sides about equal in length, apex straight and longer than fourth antennal segment; antennal hook very small, hardly retracted within eleventh segment and less than half its length; head much broader than long; propodeum very weakly angled laterally; middle femur not depressed basally; length to apex of second tergite 9 mm.

Female.—Coloration, pubescence, and puncturation about as in male. Clypeus broadly rounded-truncate apically; length to apex of second tergite 10–11 mm.

Records.—One female, Nevada (holotype); California: one male, Sobre Vista, Sonoma Co., April 31, 1910 (J. A. Kusche); one male, Cazadero, Sonoma Co., April 13, 1934 (G. E. and

R. M. Bohart); one male, Mt. Diablo, June 14, 1933 (P. H. Timberlake); one male, Mt. Diablo, May 29, 1936 (R. M. Bohart); one male, Mariposa Co., May 23, 1938 (R. M. Bohart); one female, Argus Mts., Inyo Co., May 24, 1937 (J. W. Johnson); one male, Hastings Natural History Reservation, Santa Lucia Mts., Monterey Co., May 27, 1938 (C. D. Michener); one female, San Luis Obispo Co., May; three males and one female, Little Rock, Los Angeles Co., April 11, 1936 (G. E. and R. M. Bohart); one male, Palm Springs, Riverside Co., March 25, 1916 (C. R. Fox).

This species can be separated by the characters given in the key. Outstanding are the erect hair on the clypeus and sides of the thorax, the rounded apex of the female clypeus, the hardly retracted male antennal hook, and the absence of a depression on the male middle femur. The species occurs in Nevada, and in California as far north as Sonoma County. The above is a redescription of the female and an original description of the male.

Pterocheilus hirsutipennis Bohart, new species

(Pl. II, fig. 8)

Male.—Black; mandible, labial palpus, clypeus, orbit below emargination, first two antennal segments in front, inter-antennal spot, short post-ocular stripe, front margin of pronotum, mesopleural spot, tegula, postscutellum, spot on lateral angle of propodeum, coxae and femora partly, tibiae and tarsi entirely except spot on hind tibia, apical margins of all abdominal segments except first sternite and last segment, that of second tergite with a basal V-shaped incision, a small isolated lateral spot on second sternite, lateral spot on last tergite, whitish; second and following antennal segments beneath, yellowish; wings with basal veins yellowish, apical veins brownish. Clypeus with dense silvery appressed pubescence, vertex and mesonotum with sparse erect pale hairs about three or four ocellus lengths, that on propodeum two to three ocellus lengths, first abdominal tergite with semi-erect pubescence at least two ocellus lengths, remainder of abdomen with minute appressed pubescence only; wings covered with pale hairs, thicker toward apex. Punctures on dorsum of head and thorax moderately large but separated by one puncture diameter in most cases; abdomen finely punctured, most dense on apical margins where they are separated by about two puncture diameters. Clypeus octagonal, apico-lateral sides the longest; palpus apparently two-segmented, terminal segment about three-fifths as long as broad and flattened, last two segments together almost as long as eleventh segment; lateral angle of propodeum rounded; middle femur not depressed beneath at base; second tergite as viewed from above about two-thirds as long as broad; length to apex of second tergite 6.5 mm.

Female.—Markings, pubescence, and puncturation as in male with following exceptions: Markings of head and thorax pale yellowish, clypeus black with a yellow lateral spot, tibiae partly black, tarsi reddish, apical bands of all tergites narrow and impressed on either side of middle, second sternite only with a whitish band; pubescence of mesonotum and first abdominal tergite somewhat shorter, clypeus with slight marginal pubescence only, wings thickly covered with relatively long brown to black hairs; clypeus convexo-truncate apically, sparsely punctured; length to apex of second tergite 8 mm.

Holotype male, allotype female, two male and three female paratypes, Twenty-nine Palms, San Bernardino Co., Calif., April 13, 1935, on *Isomeris arborea* (P. H. Timberlake); other paratypes, two males, Yermo, Riverside Co., May 28, 1937 (M. A. Cazier); one male, two miles south of Edom, Riverside Co., Calif., March 8, 1936 (E. G. Linsley); four females, near Edom, Riverside Co., Calif., March and April (P. H. Timberlake); one male, Palm Springs, Riverside Co., Calif., March 30, 1916 (C. L. Fox); one female, Little Rock, Los Angeles Co., Calif., March 10, 1936 (G. E. and R. M. Bohart). Holotype and allotype in California Academy of Sciences, paratypes in U. S. National Museum, and the collections of P. H. Timberlake, J. Bequaert, E. G. Linsley, and the author.

This species is characterized by its whitish markings and relatively long pubescence on the propodeum and first abdominal tergite. The only species with which it might be confused are *panamintensis* and *laticeps*. It differs from both of these in possessing on the propodeum erect hair which is two to three ocellus lengths. At present the species is known only from southern California.

Micropterocheilus Bohart, new subgenus

(Type *Pterocheilus desertorum* Bohart)

Small *Pterocheilus* less than 10 mm. in length. Male antenna thirteen segmented and simple apically. Labial palpus three segmented or sometimes in males apparently two segmented; last two segments in the female subequal in length, strongly flattened, and thickly haired. Maxillary palpus six segmented. Female mandibles relatively slender to nearly sickle-shaped, four toothed. Female clypeus usually broadly truncate apically, more rarely coming to a rounded point.

As far as I can determine from the literature, *Micropterocheilus* is peculiar to North America. It has the general appearance of *Pterocheilus* sensu stricto but the differences in maxillary and labial palpi, as well as mandibles and antennae, easily separate the two.

Pterocheilus desertorum Bohart, new species

(Pl. I, fig. 7; Pl. II, fig. 7)

Male.—Black; clypeus, mandible except at tip, first antennal segment in front, inter-antennal spot, infra-orbital stripe, post-ocular stripe, pronotum above, mesopleural spot, tegula, two small spots on scutellum, postscutellum mostly, spot on lateral angle of propodeum, legs partly, apical margins of all abdominal tergites and sternites two to six, whitish; second and following antennal segments above, legs partly, reddish brown; second and following antennal segments beneath, marks on femora and insides of tibiae, reddish; wings clear except for marginal stains. Clypeus strongly silvered but without erect hair, hair on front about two ocellus lengths, that on thorax mostly less than one ocellus length, that on abdomen minute. Clypeus weakly punctured apically; punctures of front, mesonotum, and dorsum of abdomen moderate in size and separated by a puncture diameter or less. Clypeus octagonal, apex slightly convex and shorter than latero-apical side; last antennal segment evenly rounded, not pointed apically; lateral angles of propodeum rounded; middle femur slightly beveled basally but without a distinct depression; second tergite from above about one and a third times as broad as long; length to apex of second tergite 6 mm.

Female.—Markings, pubescence, and puncturation about as in male with following exceptions: Mandibles mostly, clypeus entirely, pronotum except for two spots, scutellum, last tergite, all sternites except second, black; labial palpus brown. Clypeus almost bare, moderately punctured, apically convex, one and a third times as broad as long. Wings faintly smoky. Length to apex of second tergite 6.5 mm.

Holotype male, allotype female, eight female and eight male paratypes, Twenty-nine Palms, San Bernardino Co., Calif., April 14, 1938, on *Salix* (G. E. and R. M. Bohart); other paratypes, California: six females and two males, Olancha, Inyo Co., May 20, 1937; five females and four males, Inyo Co., one male and one female, Los Angeles Co., one female, Borego Valley, San Diego Co., April 30, 1932; Washington: One female, Lind, June 4, 1923 (M. C. Lane).

Holotype and allotype in California Academy of Sciences; paratypes in collections of U. S. National Museum, University of Kansas, Academy of Natural Sciences at Philadelphia, J. Bequaert, P. H. Timberlake, C. D. Michener, E. G. Linsley, and the author.

The black, red, and white markings of the legs, together with the entirely black clypeus in the female and normal male femora, characterize this species. Also the clypeus in the male is strongly silvered. It most closely resembles *pruinosus* which, however, has a much wider, tricolored clypeus in the female. *P. desertorum* occurs along the eastern side of the Sierras and in eastern Washington.

Pterocheilus provancheri (Huard)

(Pl. I, fig. 18, Pl. II, fig. 6)

Odynerus truncatus Provancher, 1895. Natural Canad., 22: 158 (nec Sauss.) (Holotype male, Musee du Parlement, Quebec).
Odynerus provancheri Huard, 1887. Natural Canad. 24: 25.
Leptochilus cratocerus Cam. 1909. Pom. J. Ent., 1: 122.

Black extensively marked with yellow, clypeus of female often partially black-margined. Pubescence and puncturation as in *morrisoni*. Last antennal segment in male with the point rounded, not sharp; lower surface not broadly flat and shining. Middle femur of male swollen near the base but without a baso-ventral depression. Paramere of male genitalia short and stout (pl. 2, fig. 6). Length to apex of second tergite, male 5–7 mm., female 6–8 mm.

Records.—In California *provancheri* sensu stricto occurs in the southern lowlands and north along the Sierras into Oregon, but is scarce north of Lake Tahoe. A single Idaho record is two males, Lolo Trail, Bitter Root Mts., July, 1902 (C. V. Piper). The following California counties are represented: Lassen, Sierra, Mono, Inyo, Tulare, San Bernardino, and Los Angeles (type locality). A single male specimen bears the data, Anthony-Dutchflat trail, 7,100–7,850 ft., Blue Mts., Oregon, August 8, 1929 (H. A. Scullen).

Although I have not seen the type, the description of *provancheri* fits the most abundant and widespread species in southern California, and I have examined numerous specimens from Los Angeles County, the type locality. The only other species it might be is *flavobalteatus*, but Provancher's statement that the female clypeus is a little longer than broad is not in accordance with that view.

The species can hardly be separated in the female from *morrisoni*, but in the male *provancheri*, the lack of a basal depression on the middle femur, the rounded last antennal segment, and the robust parameres separate the two species. The distribution of *morrisoni* appears to be more northerly but it does occur in the mountains of southern California and may at times fly in company with *provancheri*. Cameron's *cratocerus* from Ormsby Co., Nevada, is almost certainly this species, although it might conceivably be *morrisoni*.

Pterocheilus provancheri pruinosus Cameron

Pterochilus pruinosus Cameron, 1908. Tr. Am. Ent. Soc. 34: 227.

Typical *provancheri* is replaced in eastern Washington and Oregon, Idaho, Nevada, northeastern California, and Arizona, by a white-marked race originally described by Cameron from Arizona as a distinct

species. It appears to be morphologically identical with ***provancheri***, however. I have also seen specimens from Wyoming and Texas which appear to be ***pruinosus***, thus indicating a wide range over western North America but always in dryer sections. It is most likely to be confused with ***seneconis*** but the latter has only the abdomen whitish and is less heavily punctured as indicated in the key. The male of ***seneconis*** in addition to the above has a baso-ventral depression on the middle femur.

Records.—Washington: One female, Toppenish, July 21, 1924 (Spuler); one female, Lind, June 1, 1919 (F. W. Carlson); one female, Hatton, July, 1923, on sandhills (R. C. Shannon). Idaho: One male and one female, Hollister, June; one female, Mountain Home, June, 1931 (H. A. Water); two males and one female, Oakley, June 10, 1931 (Hinnenkamp). Oregon: One male, Warner Lake, Lake Co., June 21, 1922 (E. C. Van Dyke). California: Two males and two females, Lake City, Modoc Co., August 2, 1922 (C. L. Fox). Arizona: One female, Globe, March; one female, San Carlos Lake, May (Duncan); one female, Prescott (Cameron type). Wyoming: One male and one female, Bridger Basin (S. Garman). Texas: One male, (Belfrage) (through C. V. Riley).

Pterocheilus seneconis Rohwer

Pterochilus seneconis Rohwer, 1911. Proc. U. S. Nat. Mus., 40: 553 (type, U. S. N. M.).

Black, marked with yellow on head and thorax, whitish on abdomen, venter brown and whitish; legs brown and yellow. Puncturation relatively sparse on thorax in males and most females, very fine on abdomen especially toward bases of segments. Apical antennal segment in male terminating in a rounded point, hardly as long as segment twelve; depression of middle femur not oblique but cup-shaped and extending to the edges, slightly more than a third as long as femur; length to apex of second tergite, male 5–7 mm., female 6–8 mm.

Records.—Two males and three females, Florissant, Colorado, June, on *Senecio* (S. A. Rohwer); one male, Lake George (near Florissant), Colorado, June 18 (W. P. Cockerell); one female, Coalville, Utah, July 5, 1912 (E. R. Kalmbach).

The relationship of this species to ***morrisoni*** is very close but the whitish abdominal markings with venter brownish, and the differently shaped last antennal segment in the male indicate that it is a distinct species. The puncturation toward the bases of the abdominal segments is also finer. The species is known only from Colorado and Utah at present.

Pterocheilus morrisoni Cresson

(Pl. I, figs. 19, 23; Pl. II, figs. 5, 17)

Pterochilus morrisoni Cresson, 1879. Tr. Am. Ent. Soc., 7, Proc. p. 19 (Holotype, A. N. S. P.)

Black, extensively marked with yellow in varying amounts, clypeus often black-rimmed in female or rarely black; tarsi and antenna reddish; wings yellowish-smoky, veins reddish to brown. Pubescence of front about three ocellus lengths and fulvous, minute on thorax and abdomen. Puncturation moderate and close on head and thorax, finer toward bases of abdominal segments. Last segment of male antenna concavely flattened and shiny beneath, pointed apically; middle femur of male with a baso-ventral depression extending about a third the length of the femur; paramere of male genitalia small and slender; length to apex of second tergite, male 5–7 mm., female 6.5–8 mm.

Records.—Oregon: Ten males and ten females, Mt. Hood, timberline, July 21, 1937 (E. C. Van Dyke); two males and one female, Eagle Ridge, Klamath Lake, May and June, 1924 (C. L. Fox); Hanson's Resort, Jefferson Co., July 29, 1929 (E. C. Van Dyke). California: Siskiyou, Modoc, Lassen, Plumas, Placer, Alpine, Mono, Tuolumne, Inyo, Santa Cruz, and Santa Barbara Counties; five males and five females, Big Pines Camp, San Bernardino Co., 5000 ft., July to September, on *Eriogonum* (P. H. Timberlake). Nevada: Two males and one female, Carson City, July, 1934 (E. P. Van Duzee); holotype "Nevada." Wyoming: Grand Teton National Park, July, 1937 (F. McSwain) (albinic race?).

The female of *morrisoni* is practically identical structurally with that of *provancheri*. I have examined nearly thirty females of each from various localities and have found no structural differences. The former tends to be somewhat darker in accordance with its more northerly distribution but even this is variable. However, the males differ in antennal and femoral characters as well as the genitalic characters illustrated (Pl. 2, fig. 5).

Pterocheilus flavobalteatus Cameron

(Pl. I, fig. 25, Pl. II, fig. 4)

Pterochilus flavobalteatus Cameron, 1909. Pom. J. Ent., 1:84 (Holotype, Pomona College?).

Black, extensively marked with yellow; exposed portion of abdomen often entirely yellow except for basal rings on segments one and two; wings yellow and brown stained, veins reddish and brown. Pubescence fulvous, longest on head where it is about three ocellus lengths. Body coarsely and closely punctured, especially on dorsum of abdomen. Head about one and a third times as broad as long; clypeus squarely trun-

cate; last antennal segment of male not sharply pointed, slightly flattened but not shiny beneath; baso-ventral depression of middle femur in male at least half the length of the femur; length to apex of second tergite, male 6–8 mm., female 8–9 mm.

Records.—A single female in the collection of Pomona College is probably the holotype of this species. It bears the data, No. 5204, Durango, Colo., May 27, 1899 (Oslar). It checks with darker colored California specimens. California: One male and one female, Trinity Co., June 13, 1934 (G. E. Bohart); one female, Truckee, Placer Co., July 19, 1927 (E. P. Van Duzee); one female, Huntington Lake, Fresno Co., 7000 ft., July 4, 1919 (E. P. Van Duzee); one female, Florence Lake, Fresno Co., July, 1930 (C. D. Michener); one male, Sierra Madre Mts., Santa Barbara Co., April 24, 1926 (P. H. Timberlake); males and females, San Gabriel Mts., Los Angeles and San Bernardino Counties, April to June; one female, Sheep Creek, San Gabriel Mts., 5000 ft., June 3, 1928, on *Eriodyction trichocalyx* (P. H. Timberlake); two males and one female, Campo, San Diego Co., April 27, 1939 (R. M. Bohart); five males and five females, San Jacinto Mts., Riverside Co., May, 1939 on *Astragalus* (Linsley, Ross and Bohart).

This species belongs to a group of *Pterocheilus* including also *morrisoni* and *provancheri*. The females of these three species are often difficult to distinguish but the males are separable by several good characters. *P. flavobalteatus* has on the average the greatest proportion of yellow markings, the heaviest puncturation, and the widest head in both sexes. It also averages slightly larger than either of the other two. Typical *flavobalteatus* is distinguished from all other species in the male by the basal depression of the middle femur being at least half the length of the femur. In the subspecies *cyathopus* it is slightly less than half, in *morrisoni* it is about a third, and in *provancheri* it is absent.

Pterocheilus flavobalteatus cyathopus Bohart, new subspecies

(Pl. I, fig. 24)

Markings, pubescence, and puncturation as in typical *flavobalteatus* except that the latter tends to be somewhat yellower and more heavily punctured. Head hardly more than one and a quarter times as broad as long; middle femur in male with a basal depression reaching slightly less than half the length of the femur.

Holotype male, allotype female, seven paratype males, and three paratype females, Tuolumne Co., Calif., 3500 ft., June 9,

1938. Other paratypes, California: Sixteen males and one female, Big Meadows, Yosemite National Park, 4000 ft., May and June, 1938, on *Cryptantha;* three males, Madera Co., 3000 ft., May 27, 1938; one male, El Portal, Mariposa Co., May 18, 1938 (all type material collected by the author). Other records: seven males and four females, Mt. Diablo, Contra Costa Co., Calif., April and May (C. D. Michener, G. E. and R. M. Bohart); one male (Hastings Natural History Survey), Santa Lucia Mts., Monterey Co., Calif., June 4, 1938 (C. D. Michener). Holotype and allotype in California Academy of Sciences, paratypes in collections of U. S. National Museum, University of Kansas, J. Bequaert, P. H. Timberlake, E. G. Linsley, C. D. Michener, and the author.

Both sexes of *cyathopus* are intermediate in nearly every character between *morrisoni* and *flavobalteatus*. However, the male genitalia and antennae agree exactly with the latter species and the somewhat variable differences in head proportion, puncturation, and femoral depression of the male seem to be of racial rather than specific significance. At present *cyathopus* is known only from the central coast ranges, Mt. Diablo, and the central Sierras below 4000 feet.

Pterocheilus tricoloratus Bohart, new species

(Pl. I, fig. 31)

Female.—Black; clypeus, mandible except at apex, first antennal segment in front, lower orbital line, two inter-antennal spots, postocular dot, prothorax above, two mesopleural spots, tegula, two spots on scutellum, postscutellum, fore femur apically and fore tibia basally, mid and hind tibiae externally, apical margins of all tergites and all but first and last sternites, creamy-white; antenna, tip of mandible, propodeum, legs for most part, all tergites and first three sternites except for whitish apical margins, reddish; labial palpus, tarsi, coxae mostly, fourth to sixth sternites basally, brownish; wings almost clear, venation mostly dark brown. Pubescence sparse and short, hardly discernible on clypeus, about one ocellus length on vertex and propodeum, shorter on mesonotum, minute on abdomen. Clypeus moderately punctured especially apically; head and thorax closely covered with punctures of moderate size; abdomen well-punctured, the punctures one or more puncture diameters apart. Mandible very slender, obscurely toothed; clypeus one and two-fifths as broad as long, produced and rounded apically; lateral angle of propodeum rounded, second abdominal tergite as seen from above once and a half as wide as long; length to apex of second tergite 5.5 mm.

Holotype female, near Buckeye, Arizona, March 29, 1934, on *Heliotropium curassavicum* (P. H. Timberlake). Holotype in California Academy of Sciences.

This colorful species is the smallest of the genus known to the author. The striking black, white, and brownish-red markings are unique. The female clypeus and mandibles for the most part are white and the propodeum is reddish. The female clypeus is shaped as in no other North American species. The male is unknown but should be readily recognized by its white clypeus, red and white body markings, and its small size.

Pterocheilus acuceps Bohart, new species

(Pl. I, fig. 32)

Female:—Black; first antennal segment in front, mandible mostly, second and third segments of labial palpus, basal two-thirds of clypeus, inter-antennal spot, lower orbit, large post-ocular spot, pronotum above, tegula, two adjoining spots below, two spots on scutellum, postscutellum, a large lateral spot on propodeum, femora partly, tibiae mostly, front and middle tarsi partly, apical bands on first to fifth tergites and second sternite, those on second segment above and beneath squarely emarginate anteriorly, spot on sixth tergite, yellow; antenna, middle tarsus mostly, hind tarsus, wing veins, light to dark reddish brown; wings stained with yellow. Pubescence minute, hardly exceeding one ocellus-length at any point. Body closely and moderately punctured. Clypeus longitudinally striate, apically tapering to a rounded point, once and a half as broad as long; propodeum with a blunt lateral angle; second tergite as seen from above about once and a half as broad as long; length to apex of second tergite 7.5 mm.

Holotype female and two paratype females, Los Banos, Merced Co., Calif., May 23, 1918 (E. P. Van Duzee); one paratype female, Grand Teton National Park, Wyo., July, 1937 (J. McSwain). Holotype and paratype in California Academy of Sciences, other paratypes in collection of author.

Although the male is unknown, the female is the only known North American *Pterocheilus* with four-toothed mandibles and a pointed clypeus.

MICROFILM SETS OF PERIODICALS

The Committee on Scientific Aids to Learning, President Conant of Harvard, *Chairman*, has made a grant to cover the cost of making a microfilm master negative, on the most expensive film, of sets of volumes of scientific and learned journals.

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PROCEEDINGS OF THE THIRTY-FOURTH ANNUAL MEETING

Columbus, Ohio, December 27-29, 1939

The Entomological Society of America held its Thirty-fourth Annual Meeting on Wednesday, Thursday and Friday.

A joint symposium was held on Wednesday afternoon with the American Association of Economic Entomologists on "Fifty Years of Entomological Progress," this occasion being the fiftieth anniversary of the organization of the latter society. The subject matter of the symposium was presented chronologically, each of the five speakers on the program covering a ten year period. The development of entomology as a science, its tremendous expansion, and the external influences which have influenced its development during the period from 1889 to 1939 were well brought out by each of the speakers. One of the long to be remembered features of this symposium program was the transmission and broadcasting of a personal message from Dr. L. O. Howard at his home in Washington to the entomologists assembled in the ballroom of the Deshler-Wallick Hotel in Columbus, Ohio. Dr. Herbert Osborn presided at the symposium.

The Annual Public Address of the Society was given by Dr. A. Avinoff, Director of the Carnegie Museum, Pittsburgh, Pennsylvania, on Wednesday evening in the Hall of Mirrors of the Deshler-Wallick Hotel. The subject of the address was "Designs and Patterns in the Lepidoptera and Other Animals." Dr. Avinoff analyzed and interpreted the designs and patterns of butterflies, moths and other animals based on a study of slices made through various sorts of geometrical figures. The address, illustrated with lantern slides and kodachrome slides was exceedingly stimulating and thought provoking. Approximately four hundred and fifty persons were in attendance.

The Entomologists' Dinner was held on Thursday evening in the Ballroom of the Deshler-Wallick Hotel, and was given over entirely to the celebration of the fiftieth anniversary of the organization of the American Association of Economic Entomologists. The dinner was featured by the presentation of an enormous birthday cake adorned with fifty candles and neon lighted. After an exceptionally good dinner those present enjoyed an unusually interesting program of entertainment which had been arranged by the local committee.

The Thursday morning session was a joint one participated in by the Ecological Society of America and our own Society. Eight papers were presented dealing with subjects in the field of insect ecology.

The attendance at the Columbus meeting was probably greater than any in recent years. Approximately two hundred and fifteen persons registered at the secretary's desk, and it is known that there were many who did not register.

The program presented at the three-day meeting follows:

Opening Session, Wednesday Morning, December 27

The Society was called to order at 9:30 A. M. by PRESIDENT E. M. WALKER in Parlors A-B-C, DESHLER-WALLICK HOTEL. PRESIDENT WALKER appointed the following committees:

Nominating Committee—A. L. MELANDER, *Chairman;* E. O. ESSIG, A. F. SATTERTHWAITE.

Resolutions Committee—Z. P. METCALF, *Chairman;* ANNETTE F. BRAUN, ROGER C. SMITH.

Auditing Committee—H. H. SHEPARD, *Chairman;* M. C. TANQUARY, R. C. OSBURN, HOWARD O. DEAY.

The following papers were presented:

1. Some Micromethods in Entomology. (15 min.) (Lantern). C. S. WILSON, Bureau of Entomology and Plant Quarantine, Washington, D. C.
2. Arkansas Cyclocephalini with Notes on Some Related Species (Coleoptera, Scarabaeidae). (5 min.) MILTON W. SANDERSON, University of Arkansas, Fayetteville, Arkansas.
3. Glycogen Counts from Blood of *Prodenia eridania* Cram. with Reference to Effects of Poison Administration. (25 min.) (Lantern.) J. FRANKLIN YEAGER AND SAM C. MUNSON, Bureau of Entomology and Plant Quarantine, Washington, D. C.
4. Pairing Between Males and Females and Between Males of Different Species of Moths. (5 min.) (Lantern.) JOSEPH L. WILLIAMS, Lincoln University, Pennsylvania.
5. The External Anatomy of *Psectra diptera* (Burmeister), (Neuroptera, Sympherobiidae). (5 min.) (Lantern.) LEE H. TOWNSEND, University of Kentucky, Lexington, Kentucky.
6. A Neotropical Mantispid Emerges from a Spider Egg Mass. (5 min.) H. E. MILLIRON, University of Minnesota, St. Paul, Minnesota.
7. *Montezumia, Monobia* and *Pachymenes*, Neotropical Elements in the Nearctic Fauna. (By title.) JOSEPH C. BEQUAERT, Harvard Medical School, Boston, Massachusetts.
8. Observations on the External Morphology of the Corn Seed Beetle, *Agonoderus pallipes* Fabr. (Carabidae). (10 min.) HARRY R. BRYSON, Kansas State College, Manhattan, Kansas.
9. The Biology of the Black Blister Beetle. (10 min.) (Lantern.) W. R. HORSFALL, University of Arkansas, Fayetteville, Arkansas.
10. The History and Biology of the Juniper Midge, *Contarinia juniperina* Felt. (10 min.) LEONARD HASEMAN AND S. R. MCLANE, University of Missouri, Columbia, Missouri.
11. The Hornworm Parasite, *Apanteles congregatus* Say and the Hyperparasite *Hypopteromalus tabacum* Fitch. (15 min.) (Lantern.) B. B. FULTON, North Carolina State College, Raleigh, North Carolina.

The Society then adjourned to meet with the AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS to hear the address of their president, MR. E. R. SASSCER.

Second Session, Wednesday Afternoon, December 27

JOINT SESSION WITH AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Symposium: "Fifty Years of Entomological Progress"

The session was called to order by DR. HERBERT OSBORN at 2:30 P. M. A short talk was given by DR. L. O. HOWARD from his home in Washington, D. C. This was transmitted and broadcast to those assembled for the symposium. The following papers were then presented:

The Decade 1889 to 1899—C. L. MARLATT, Washington, D. C.
The Decade 1899 to 1909—LAWSON CAESAR, Ontario Agricultural College, Guelph, Ontario, Canada.
The Decade 1909 to 1919—C. L. METCALF, University of Illinois, Urbana, Illinois.
The Decade 1919 to 1929—E. O. ESSIG, University of California, Berkeley, California.
The Decade 1929 to 1939—S. A. ROHWER, Bureau of Entomology and Plant Quarantine, Washington, D. C.

Third Session, Wednesday Evening, December 27

The session was called to order by PRESIDENT E. M. WALKER at 8:00 P. M. PRESIDENT WALKER introduced the speaker of the evening, DR. AVINOFF, Director of the Carnegie Museum, Pittsburgh, Pennsylvania, who spoke on the subject "Designs and Patterns in Lepidoptera and Other Animals." The lecture was illustrated with lantern slides and kodachrome slides. Approximately four hundred and fifty persons were present.

Fourth Session, Thursday Morning, December 28

JOINT SESSION WITH THE ECOLOGICAL SOCIETY OF AMERICA

The session was called to order by DR. CLARENCE H. KENNEDY at 9:30 A. M. and the following papers were presented:

12. Environmental Resistance to the Establishment of Imported Parasites. (15 min.) STANLEY E. FLANDERS, Citrus Experiment Station, Riverside, California.
13. Studies of Growth Weights and Food Requirements of Certain Insects. (12 min.) (Lantern.) W. W. STANLEY AND S. MARCOVITCH, Tennessee Agricultural Experiment Station, Knoxville, Tennessee.
14. Calculated and Obtained Populations of *Microbracon hebetor* Say (Hymenoptera, Braconidae) and Its Host, *Ephestia kuehniella* Zeller (Lepidoptera, Pyralidae) with Reference to Maximum and Minimum Fluctuations. (15 min.) NELLIE M. PAYNE, American Cyanamide Co., Stamford, Connecticut.
15. Relative Prevalence of Potato Flea-beetle, *Epitrix cucumeris* Harr., Injuries in Fields Adjoining Uncultivated Areas. (8 min.) (Lantern.) D. O. WOLFENBARGER, Bureau of Entomology and Plant Quarantine, Bloomfield, New Jersey.
16. Autecology of the Goldenrod Gall Fly. (15 min.) (Lantern.) LORUS J. MILNE, Randolph-Macon Woman's College, Lynchburg, Virginia.
17. The Diphyletic Origin of the Nasute Soldier of Termites. (10 min.) (Lantern.) ALFRED E. EMERSON, University of Chicago, Chicago, Illinois.
18. Quantitative Study of the Recent Emergence of the Periodical Cicada in the Chicago Area. (15 min.) (Lantern.) ELDON J. STRANDINE, Northwestern University and North Park College, Chicago, Illinois.
19. Inter-specific Competition in Experimental Laboratory Populations. (By title.) THOMAS PARK, University of Chicago, Chicago, Illinois.
20. An Ecological Study of the Floor Fauna of the Panama Rain Forest. (15 min.) (Lantern.) ELIOT C. WILLIAMS, JR., Northwestern University, Evanston, Illinois.

Fifth Session, Thursday Afternoon, December 28

Following the call to order at 2:00 P. M. by PRESIDENT WALKER, the following papers were presented:

21. A Tachinid Parasite of *Myodacha serripes* Olivier. (5 min.) (Lantern.) B. D. BURKS, State Natural History Survey, Urbana, Illinois.
22. Improved Riker Insect Mount for Use in Teaching. (5 min.) RALPH H. SMITH, University of California at Los Angeles, Los Angeles, California.

23. Kodachrome, Natural Color Film, as an Aid in Entomological Work. (15 min.) (Kodachrome slides.) EDWARD S. THOMAS, Ohio State Museum, Columbus, Ohio.
24. Variation of the Internal Genitalia of Closely Related Moths and Disproof of Pictet's Ideas of Double Copulation. (15 min.) (Lantern.) JOSEPH L. WILLIAMS, Lincoln University, Pennsylvania.
25. How Many Insects Are There in the World? (10 min.) (Lantern.) Z. P. METCALF, North Carolina State College, Raleigh, North Carolina.
26. Life History of *Phymata pennsylvanica americana* Melin. (15 min.) W. V. BALDUF, University of Illinois, Urbana, Illinois.
27. The Genus *Hesperia*. (10 min.) A. W. LINDSEY, Denison University, Granville, Ohio.
28. Is Ours the "Age of Insects"? (15 min.) (Lantern.) C. T. BRUES, Harvard University, Cambridge, Massachusetts.
29. Terminology of Hymenopterous Wings. (10 min.) (Lantern.) HERBERT H. ROSS, State Natural History Survey, Urbana, Illinois.
30. The Nuptial Flight of the Ephemeroptera. (10 min.) HERMAN T. SPIETH, College of the City of New York, New York.
31. *Xylococcus betulae* Perg. Attacking Willow. (10 min.) (Lantern.) J. S. HOUSER, Ohio Agricultural Experiment Station, Wooster, Ohio.

Sixth Session, Friday Morning, December 29

The Society was called to order at 9:00 A. M. by SECRETARY MICKEL for a special showing of a colored motion picture film, "The Life History of the Rocky Mountain Wood Tick," which had recently been completed by the Public Health Laboratory, Hamilton, Montana. DR. C. B. PHILIP of that laboratory made comments as the film was shown. At 9:30 A. M. PRESIDENT WALKER took charge of the meeting and the following papers were presented:

32. Some Insects of 1939. (18 min.) (Motion pictures.) A. L. MELANDER, City College of New York, New York.
33. A New Parasite of *Anthrenus vorax* Waterhouse. (10 min.) (Lantern.) E. A. BACK, Bureau of Entomology and Plant Quarantine, Washington, D. C.
34. Water Vapor as a Factor Affecting the Survival of Insects at Reduced Pressures. (10 min.) ERSKINE M. LIVINGSTON AND W. D. REED, Bureau of Entomology and Plant Quarantine, New Orleans, Louisiana, and Richmond, Virginia.
35. The Inheritance of Resistance to HCN Fumigation in *Aonidiella aurantii* (Mask.). (15 min.) (Lantern.) H. J. QUAYLE AND R. C. DICKSON, Citrus Experiment Station, Riverside, California.
36. A Summary of North American Chrysopid Types seen in European Museums. (10 min.) (Lantern.) ROGER C. SMITH, Kansas State College, Manhattan, Kansas.
37. Some Suggestions about the Common Names of Insects. (7 min.) (Lantern.) C. L. METCALF, University of Illinois, Urbana, Illinois.
38. Entomological Usage of Subspecific Names. (15 min.) (Lantern.) CURTIS W. SABROSKY, Michigan State College, East Lansing, Michigan.
39. The Distribution of Kentucky *Phyllophaga*. (12 min.) (Lantern.) PAUL O. RITCHER, Kentucky Agricultural Experiment Station, Lexington, Kentucky.
40. The Role of Insect Reproductive Organs in the Dissemination and Inoculation of Plant Pathogens. (12 min.) (Lantern.) A. A. GRANOVSKY, University of Minnesota, St. Paul, Minnesota.

Seventh Session, Friday Afternoon, December 29

Following the call to order at 2:00 P. M. by PRESIDENT WALKER, the following papers were presented:

41. Pathology of the Intestine of the Boll Weevil Following the Ingestion of Calcium Arsenate. (12 min.) (Lantern.) R. W. LEIBY, Cornell University, Ithaca, New York.
42. Some New Species of Corixidae. (8 min.) (Lantern.) H. B. HUNGERFORD, University of Kansas, Lawrence, Kansas.
43. Some Recent Works on the Classification of Immature Insects. (10 min.) WM. P. HAYES, University of Illinois, Urbana, Illinois.
44. Notice of an Index to the Literature on North American Siphonaptera by Wm. L. Jellison and Newell E. Good. (8 min.) NEWELL E. GOOD, U. S. Public Health Service, San Francisco, California.
45. The Distribution of Insect Orders in the Southern Tundra. (5 min.) V. E. SHELFORD, University of Illinois, Urbana, Illinois.

The following is a report of the Annual Business Meeting which was held Friday afternoon, December 29, following the paper reading session:

REPORT OF THE SECRETARY

During the year 1939, the following having been duly nominated and recommended, were elected members of the Society by mail ballot of the Executive Committee:

F. ATHERTON RIEDEL, 1340 Corona St., Denver, Colorado.
LEWIS T. GRAHAM, Dept. of Zoology and Entomology, Iowa State College, Ames, Iowa.
PHILIP H. HARDEN, Division of Entomology, University Farm, St. Paul, Minn.
HUGO HARTNACK, 608 S. Dearborn St., Chicago, Illinois.
CARLOS C. HOFFMANN, Apartado 8026, Mexico, D. F., Mexico.
WILLIAM EDWARD SIMONDS, Agriculture Bldg., Embarcadero and Mission, San Francisco, California.
TOICHI UCHIDA, Hokkaido Imperial University, Sapporo, Japan.
LEONILA VASQUEZ, care Instituto de Biologia, Casa del Lago, Chapultepec, D. F., Mexico.
MIKE WRIGHT, Dept. Zoology and Entomology, Ohio State University, Columbus, Ohio.

With the approval of the Executive Committee a joint symposium on the subject, "Fifty Years of Entomological Progress," was arranged for with the American Association of Economic Entomologists.

With the approval of the Executive Committee a joint session with the Ecological Society of America was arranged for the Columbus meeting.

DR. NEALE F. HOWARD kindly consented to act as chairman of the local committee on arrangements at Columbus to represent both entomological societies and was so appointed by PRESIDENT WALKER. DR. D. M. DELONG, DR. F. M. CAMPBELL, PROFESSOR T. H. PARKS, PROFESSOR J. S. HOUSER and DR. ALVAH PETERSON also represented the Entomological Society of America on this committee. PROFESSOR JOSEF N. KNULL was appointed by the President to co-operate with DR. HAROLD WATERS, of the American Association of Economic Entomologists in arranging and supervising the exhibits of the Society at the Columbus meeting.

The Secretary met with PRESIDENT E. R. SASSCER and PROFESSOR W. P. FLINT, of the American Association of Economic Entomologists, on March 24, 1939, at St. Paul, Minnesota, and arranged for the joint symposium of the two societies at Columbus.

With the approval of the Executive Committee, DR. A. AVINOFF, Director of the Carnegie Museum, Pittsburgh, Pa., was invited to give the Annual Public Address at the Columbus meeting.

The Executive Committee voted by mail ballot to authorize the Secretary to negotiate with the Secretary of the American Association of Economic Entomologists regarding a five-year program of places for holding the annual meetings of the two societies.

PROFESSOR A. C. KINSEY was appointed by PRESIDENT WALKER to represent the Society in its relations with the Union of American Biological Societies.

DR. P. P. CALVERT resigned as the Advisory Representative of the Society on the Committee of the Division of Biology and Agriculture of the National Research Council. PRESIDENT WALKER appointed PROFESSOR E. O. ESSIG to replace DR. CALVERT.

The Executive Committee met at 7:30 P. M., December 26, at the Deshler-Wallick Hotel, Columbus, Ohio, the following officers being present: E. A. WALKER, CLARENCE H. KENNEDY and CLARENCE E. MICKEL. Two other members of the Executive Committee were present: ALFRED E. EMERSON and S. A. GRAHAM. The following alternates designated by the President, served in place of absent members of the committee: E. O. ESSIG and WILLIAM P. HAYES.

The following were elected to membership in the Society:

T. L. AAMODT, State Entomologist's Office, University Farm, St. Paul, Minnesota.

OTTO ACKERMANN, 639 Walnut St., Irwin, Pennsylvania.

PAUL B. ALLEN, JR., 820-B Washington Ave., Wenatchee, Washington.

FLOYD ANDRE, Bureau of Entomology and Plant Quarantine, Washington, D. C.

AMOS EDISON BADERTSCHER, McCormick and Co., Light and Barre Sts., Baltimore, Maryland.

JOHN P. BARRETT, 7213 Yates Ave., Chicago, Illinois.

LAWRENCE MATTHEWS BARTLETT, Fernald Hall, Massachusetts State College, Amherst, Massachusetts.

JUDSON J. BEOUGHER, R. F. D. 1, Laurelville, Ohio.

RAIMON L. BEARD, Connecticut Agricultural Experiment Station, 123 Huntington St., New Haven, Connecticut.

PAUL A. BERRY, Bureau of Entomology and Plant Quarantine, Washington, D. C.

AUBERN E. BROWER, 5 Hospital St., Augusta, Maine.

A. W. A. BROWN, Division of Entomology, Department of Agriculture, Ottawa, Ontario, Canada.

MABEL COLCORD, 2520 Fourteenth St., N. W., Washington, D. C.

OLIVER B. COPE, Natural History Museum, Stanford University, California.

ROBERT H. CRANDALL, 2208 E. Third St., Tucson, Arizona.

ROBERT C. DICKSON, Department of Entomology, Citrus Experiment Station, Riverside, California.

LYLE HARRIS EDELBLUTE, 1212 A Thurston St., Manhattan, Kansas.

PERRY A. GLICK, Box 1218, Waco, Texas.

JOHN FRANCIS HANSON, Fernald Hall, Amherst, Massachusetts.

WILLIAM J. HAUDE, care John Powell and Co., Inc., 114 E. 32nd St., New York, N. Y.

JAMES KEEVER HOLLOWAY, Box 491, Orlando, Florida.

CHARLES L. HOVEY, Division of Entomology, University Farm, St. Paul, Minnesota.

ADELBERT FREDERICK HOWLAND, P. O. Box 287, Alhambra, California.

JOHN H. HUGHES, 81 South St., Jackson, Ohio.

JOHN W. JOHNSON, Division of Entomology and Parasitology, University of California, Berkeley, California.

J. R. J. LLEWELLYN JONES, "Arranmore," R. M. D. 1, Cobble Hill, British Columbia, Canada.

HUGH BOSDIN LEECH, P. O. Box 308, Vernon, British Columbia, Canada.

C. C. LINCOLN, Department of Entomology, Cornell University, Ithaca, New York.

ARTHUR W. LINDQUIST, Nice, Lake Co., California.

EUGENE WARREN MENDENHALL, 97 Brighton Road, Columbus, Ohio.

ROBERT LEE METCALF, 704 Pennsylvania Ave., Urbana, Illinois.

ROBERT T. MITCHELL, Department of Zoology and Entomology, Ohio State University, Columbus, Ohio.

GEORGE A. MOORE, 359 Querbes Ave., Outremont, Quebec, Canada.

WARREN MOORE, Bon Air, Virginia.

HERBERT H. J. NESBITT, 34 Lakeside Ave., Ottawa, Ontario, Canada.

CHARLES EDMUND PALM, Department of Entomology, Cornell University, Ithaca, New York.

BARBARA MINER PARKER, 416 E. 47 Terrace, Kansas City, Missouri.

ALLAN G. PETERSON, Division of Entomology, University Farm, St. Paul, Minnesota.

MANUEL MARK PETRAKIS, Department of Entomology, University of Illinois, Urbana, Illinois.

GEORGE HENRY PLUMB, Agricultural Experiment Station, New Haven, Connecticut.
GARLAND T. RIEGEL, 304 Entomology Bldg., University of Illinois, Urbana, Illinois.
ROY W. RINGS, 70 South Burgess Ave., Columbus, Ohio.
RURIC CREEGAN ROARK, Bureau of Entomology and Plant Quarantine, Washington, D. C.
EDWARD S. ROSS, Department of Entomology, California Academy of Science, San Francisco, California.
CLIFFORD SYMES RUDE, 234 N. Washington, Gainesville, Florida.
LESLIE M. SMITH, University of California Deciduous Fruit Station, Route 1, Box 92, San Jose, California.
MYRON W. SMITH, 113 West Rich St., Columbus, Ohio.
BENJAMIN THOMAS SNIPES, Escola Superior de Agricultura e Veterinaria, Vicosa, Minas Gerais, Brazil.
EUGENE M. STAFFORD, Comstock Hall, Cornell University, Ithaca, New York.
WILLIAM LOUDEN THOMPSON, Box 1074, Lake Alfred, Florida.
ROBERT TRAUB, Department of Entomology, University of Illinois, Urbana, Illinois.
HELEN LOUISE TREMBLEY, Bureau of Entomology and Plant Quarantine, Washington, D. C.
CARL J. WEINMAN, 308 N. State St., Champaign, Illinois.
RUPERT LEON WENZEL, 640 Belden Ave., Chicago, Ill.
HARRY H. WHALL, Mount Hope Cemetery, Jackson Ave., Hastings-On-Hudson, New York.
CHARLES S. WILSON, Bureau of Entomology and Plant Quarantine, National Research Center, Beltsville, Md.

The total number of new members for the year 1939 is 65.

The following have resigned during the year: MRS. A. P. ARANSON, HAROLD L. BAILEY, WM. H. BENNETT, RICHARD E. BLACKWELDER, MARK F. BOYD, H. G. BUTLER, W. M. DAVIDSON, A. C. DAVIS, ERNST J. DORNFELD, GEORGE DE GHIKA, HAROLD C. HALLOCK, FRANK G. HINMAN, J. R. HORTON, LEE R. JEPPSON, KIMBER C. KUSTER, DONALD S. LACROIX, ALEXANDER W. LEVI, JAMES MCDUNNOUGH, ANDREW J. MUTCHLER, L. H. PATCH, CALVIN A. RICHINS, E. W. K. SCHWARZ, CAMERON SIDDALL, CHARLES T. VORHIES, A. O. WEESE, R. M. WHITE, and W. E. WATKINS.

The following have been automatically dropped from membership either because of failure for three or more years to pay dues or because they cannot be reached: MRS. REED O. CHRISTENSON, JOHN T. GAMBLE, PERCY I. LATHY, ELMER T. LEARNED, THEUNIS J. NAUDE, FRIAR M. THOMPSON, JR.

The Executive Committee by unanimous vote nominated the following Honorary Fellows and they were elected by the Society: P. P. CALVERT, O. A. JOHANNSEN, C. W. WOODWORTH.

The Executive Committee elected the following Fellows: W. C. ALLEE, P. N. ANNAND, A. AVINOFF, ANGELO M. DE COSTA-LIMA, WM. A. HILTON, WM. E. HOFFMANN, THEO. H. HUBBELL, ISABEL MCCRACKEN, D. E. MINNICH, A. W. MORRILL, R. H. PETTIT, WM. ROBINSON, H. C. SEVERIN, HAROLD H. SHEPARD, JOHN D. SHERMAN, JR., A. FRANKLIN SHULL, F. M. WADLEY, J. R. WATSON, R. S. WOGLUM, JAMES ZETEK.

The Society has suffered loss by death of the following seven members during the past year: CHARLES N. AINSLIE, W. E. BRITTON, ROYAL N. CHAPMAN, L. O. ELLISOR, CHARLES R. ELY, H. C. FALL, H. F. WILLARD.

CHARLES NICOLAS AINSLIE, a member of our Society since 1908 and a Fellow since 1931, was born near Hagaman's Mills, New York, October 13, 1856, and died at Sioux City, Iowa, December 5, 1939. He attended Beloit College in Wisconsin from which he graduated in 1877. After graduating from college he entered the banking business in Rochester, Minnesota, and until 1906 was assistant cashier of the First National Bank there. During these years at Rochester he was an inveterate collector of insects and a student of their life histories and habits and became a close friend of Professor Otto Lugger, who was at that time State Entomologist of Minnesota. He was also a friend and correspondent of the late F. M. Webster and in 1906 joined the staff of the Bureau of Entomology to work on cereal and forage crop insects. He remained in the employ of the Bureau of Entomology until 1930 when he retired because of age, but was continued as a collaborator

with the U. S. National Museum. After his retirement he continued his collecting and amassed a collection of considerable size, a large part of which was determined by specialists with whom he was acquainted. A part of this collection has been deposited in the U. S. National Museum and the remainder he presented as a gift to the University of Minnesota. During his life time he published many brief papers on the life histories and habits of insects. Mr. Ainslie was a naturalist of the old school who had unbounded enthusiasm for learning about insects. This enthusiasm was maintained almost until the day of his death. He shared this enthusiasm with his son George, deceased, a member of our Society and a student of the Lepidopterous family Crambidae. He is survived by two sons, Arthur, of Minneapolis, Minnesota, and Kenneth, of Sioux City, Iowa.

WILTON EVERETT BRITTON, a charter member of our Society and a Fellow since 1914, was born at Marlboro, Massachusetts, September 18, 1868, and died at New Haven, Connecticut, February 15, 1939. His elementary education was received in rural schools. In 1893 he received the degree of Bachelor of Science from the New Hampshire College of Agriculture and Mechanic Arts (now the University of New Hampshire). After a year of graduate study in horticulture at Cornell University he became horticulturist at the Connecticut Agricultural Experiment Station in 1894. In 1901 he was appointed Station and State Entomologist, serving until his death. In 1901 and 1905 he was lecturer in Forest Entomology at Yale University. He received the degree of Doctor of Philosophy from Yale University in 1903. In 1930 the University of New Hampshire awarded him the honorary degree of Doctor of Science. In 1936 the Connecticut State College awarded him "Honorary Recognition" as a leader in agriculture and rural life. He was Superintendent of the Connecticut State Geological and Natural History Survey from 1925 until he died. Although Doctor Britton's early scientific work was in the fields of horticulture and botany, most of his professional life was devoted to entomology. He published a large number of papers on insects of economic importance, and his annual Reports of the State Entomologist of Connecticut, published continuously since 1901, are models of their kind. He personally contributed to the entomological bulletins of the State Geological and Natural History Survey, writing an introduction to the series, the parts dealing with Aleyrodidae and Coccidae in the Hemiptera, and the Check-List and its Supplement. He was a Fellow of the American Association for the Advancement of Science, president of the American Association of Economic Entomologists in 1909 and associate editor of the Journal of Economic Entomology from 1909 to 1928. Aside from his scientific interest, Doctor Britton had a keen civic consciousness and served his community well. He was twice president of the local civic association, president of the Donald G. Mitchell Library, director of the New Haven Public Library and the New Haven Young Men's Institute, chairman of the Committee on Food of the New Haven War Bureau and member of the 2nd Company Governor's Foot Guard during the World War, and active in many other civic and agricultural organizations. In his personal life and associations with others, Doctor Britton exhibited an inherent worthiness of character, a keen intelligence, and remarkable sense of fairness. Pleasant, tactful, and considerate, yet rigorously honest and tenacious in his adherence to what he conceived to be the right course, he was held in highest esteem. In 1895 he married Miss Bertha Madeline Perkins, who died in 1938. There were no children.

ROYAL NORTON CHAPMAN, a member of our Society since 1914 and a Fellow since 1927, was born in Morristown, Minnesota, September 17, 1889, and after a brief illness died December 2, 1939, in the full zenith of his powers. He early exhibited the love for nature which marked all his life. On graduation from Pillsbury Academy he entered the University of Minnesota, where he majored in Zoology and graduated in 1914. In his undergraduate work he came into intimate relations with Oscar W. Oestlund, who stimulated his interest in entomology and particularly its ecological aspects. His Master's thesis, 1915, was "The External Morphology of *Agrilus bilineatus*" and was supplemented by a biological study of the same species. In 1915–16 he held a fellowship in Entomology at Cornell University, where he completed his doctorate under Professor Comstock in 1917. He was appointed instructor in Zoology in his Alma Mater in 1917 and in 1918 advanced to an assistant professorship and given the added rank of assistant entomologist in the Agricultural Experiment Station. His advancement was

rapid—associate professor in 1923, professor and chief of the Division of Entomology and Economic Zoology, 1925–30, and in the meantime holder of a Guggenheim Fellowship and traveling professor in Europe under the Rockefeller Foundation, 1926–27. In 1930 he went to Hawaii as Director of the Pineapple Producers Cooperative Associations Experiment Station and Dean of the Graduate School of Tropical Agriculture of the University of Hawaii. In July, 1939, he returned to the University of Minnesota as dean of the Graduate School. Interested as he was in educational work he was very happy in his new work and had taken hold of the many problems with his characteristic alertness and interest in the welfare of the students with whom he came in contact. News of his death came as a great shock to the entire University community and to his hosts of friends in widely scattered parts of the world. Dr. Chapman's conception of the necessity of a fundamental approach to the problems of applied zoology is evidenced in his "Animal Ecology," a work which has received world-wide recognition. His wide range of interest, his sympathetic nature and his sterling character endeared him to all who learned to know him. His wife, Helen Sanborn Chapman, two daughters and a son survive him.

LEWIE OWEN ELLISOR, a member of our Society since 1934, was born at Willis, Texas, on January 18, 1910, and died at Baton Rouge, Louisiana, October 21, 1939. He graduated from the Texas Agricultural and Mechanical Arts College in 1932 and immediately entered upon graduate study in entomology at Iowa State College, obtaining the Master of Science degree in 1934 and the Doctor of Philosophy degree in 1935 from that institution. After a short period in the employ of the Bureau of Entomology and Plant Quarantine as junior entomologist, he became in 1936 assistant entomologist of the Louisiana Agricultural Experiment Station, a position he held until his death. Early in his career as a graduate student, Dr. Ellisor demonstrated an ability for close, careful work on the toxicology of insects. He became interested not only in the gross effects of poisons, but in the details of their distribution within the organism. Some of his first published work was in this field. This interest continued into his professional career; but time for such studies was limited by the pressure of other problems and soon by failing health. At the Louisiana Experiment Station he took up in earnest the economic problems that fell to his jurisdiction. Always a hard worker, he entered upon these tasks with energy and enthusiasm and in a short time had made worthwhile contributions on toxicology and on the life-histories and control of several insects. His cheerful, friendly disposition and sound, well-informed mind made his presence valuable in the classroom, the laboratory, and in an advisory capacity on the farm. Without doubt his untimely death interrupted a promising career in entomology. He is survived by his wife, Dorothy Raine Ellisor, and a daughter, Jean.

CHARLES RUSSELL ELY, a member of our Society from 1911, was born at Columbus, Ohio, February 20, 1870, and died at Washington, D. C., February 22, 1939. Practically all of his mature life he was associated with teaching in schools for the deaf, going to Gallaudet College, Washington, D. C., as instructor in natural sciences in 1892, and becoming its vice-president in 1920; one year, 1912–13, he was principal of the Maryland School for the Deaf. His researches lead to published results in several sciences, his entomological studies centering about the families Pyralidae and Gracilariidae of the Lepidoptera. We are informed by current microlepidopterists that Dr. Ely's conclusions, based on wing venation and biology, are supported by more recent work including the fundamental relationships disclosed by examination of genitalia, and that his studies of the Gracilariidae were among the finest ever conducted in America. Two years, 1916 and 1917, he was President of the Entomological Society of Washington, and a list of his ten entomological papers appears in the April, 1939, Proceedings of that society. Dr. Ely was graduated by Yale University in 1891 and received a doctorate from George Washington University in 1900. His wife, Louise Crane Ely, and their three daughters and four grandchildren survive him.

HENRY CLINTON FALL, a charter member of our Society and a Fellow since 1907, was born at Farmington, N. H., December 25, 1862, and died at Tyngsboro, Mass., November 13, 1939. He graduated from Dartmouth College in 1884, and was given the honorary degree, Doctor of Science, in 1929. He taught for a time in Chicago, and for many years in southern California. Retiring, he came East to occupy the former home of his close friend, Frederick Blanchard. He devoted

himself almost entirely to American Coleoptera, amassing a collection of over 220,000 specimens, 14,500 named species in excellent condition and arrangement. He published numerous articles, revising several families and many genera, describing as new about 1,400 species. He had visited, often several times, the various museums and collections for comparison with types, thereby materially enhancing the value of his collection. His death realizes his greatest wish, that his own collection should rest beside that of Leconte which he knew and loved so well.

HAROLD FRANCIS WILLARD, a member of our Society since 1927 and a Fellow since 1938, was born at Neillsville, Wisconsin, on February 21, 1884, and died on August 18, 1939, at Honolulu, Hawaii. Following his graduation from Massachusetts Agricultural College in 1911 he accepted a position in Honolulu as an instructor in agriculture and practical fruit growing at Mills College, a military school for Polynesian and Oriental students. Approximately three years were devoted to this work, after which he resigned to become a homesteader of Government land in and about Haiku, Island of Maui. In 1916 Mr. Willard entered the Bureau of Entomology of the U. S. Department of Agriculture, and remained continuously in that Bureau and the Bureau of Entomology and Plant Quarantine until his death. He was associated with Messrs. E. A. Back and C. E. Pemberton in the early research work in Hawaii on the Mediterranean fruitfly and melon fly and was in charge of these activities over a period of years. He published an important series of papers on field parasitization of the Mediterranean fruitfly between 1918 and 1927. His work as a regulatory official was outstanding and he enjoyed in an unusual degree the confidence of the growers, shippers, and transportation officials. Mr. Willard was married in 1911 to Miss Mary Hyatt, of Leominister, Mass., who preceded him in death in 1935. Surviving are his son, Harold Francis, Jr., of Honolulu, and three brothers and two sisters, all living in Massachusetts. He was a member of the American Association of Economic Entomologists and the Hawaiian Entomological Society. In the last named organization he took an active interest, serving as Secretary for many years and as its President in 1926.

Following the reading of these brief memorials the members stood in silence in memory of the seven who have died during the past year.

The total membership on December 31, 1939, is 977.

The following were elected by the Executive Committee to the Editorial Board of the Annals: to fill out the term ending December 31, 1940, of JAMES MCDUNNOUGH, resigned, W. J. BROWN; for the three year term ending December 31, 1942, E. GORTON LINSLEY, C. F. W. MUESEBECK, WM. PROCTER.

The following were elected by the Executive Committee to the Thomas Say Foundation Committee for the two year term ending December 31, 1941: A. C. KINSEY, E. O. ESSIG.

The Executive Committee voted to contribute $10.00 towards the expenses of the Biologists' Smoker at Columbus, Ohio.

The Executive Committee voted to contribute $50.00 to the Zoological Society of London for the support of the Zoological Record.

The Executive Committee elected J. N. KNULL to the Joint Committee on Insect Collections for the three year term ending December 31, 1942.

The Executive Committee voted to hold the 1940 Annual Meeting at Philadelphia, Pennsylvania, at the same time as the meetings of the American Association for the Advancement of Science, and also approved a joint agreement with the Executive Committee on the American Association of Economic Entomologists for the following schedule of meeting places for the next five years, and a tentative schedule for the second five year period: 1940, Philadelphia; 1941, San Francisco or Berkeley, California; 1942, New York; 1943, San Antonio, Texas; 1944, Chicago; 1945, Atlanta, Georgia; 1946, Toronto, Canada; 1947, Kansas City, Missouri; 1948, Atlantic City, New Jersey; 1949, Cincinnati.

Respectfully submitted,

CLARENCE E. MICKEL, *Secretary.*

On motion the Secretary's Report was accepted and the recommendations of the Executive Committee adopted.

REPORT OF THE TREASURER

Current Funds

RECEIPTS

Balance on hand in Bank, December 17, 1938 (See Annals, Vol. 32, p. 234)	$2,255.23
From Annual Dues of Members to December 20, 1939	3,680.69
From Clarence H. Kennedy, Managing Editor of Annals	650.00
From Four Life Memberships—A. Earl Pritchard, E. A. Back, W. Donald Murray, and R. W. Burrell	200.00
From Sale of Four Membership Lists	3.50
From Sale of Reprints	.86
Total	$6,790.28

EXPENDITURES

Postage, including 3,000 three-cent stamped envelopes and 1,000 one and one-half cent envelopes	$ 118.28
Spahr and Glenn Printing Co., Printing December, 1938, and March, June and September, 1939, Annals	3,998.06
Letterheads for President and Secretary-Treasurer and stamped envelopes for President	14.06
Printing preliminary announcements, blank forms and programs	126.50
Clerical services	46.00
Biologists' Smoker, Richmond Meeting	10.00
Contribution to Zoological Society of London for Zoological Record	50.25
Expenses in connection with Richmond Meeting	30.84
Travel expenses of Secretary-Treasurer to Richmond Meeting	80.35
Member badges for annual meetings	22.50
Checks returned by bank	16.25
Exchange on checks at bank	28.98
Transfer of Life Membership payments to Permanent Fund—A. Earl Pritchard, E. A. Back, W. Donald Murray, and R. W. Burrell	200.00
Total	$4,742.07
Balance in checking account December 20, 1939	2,048.21
Total	$6,790.28

Liabilities

The Society owes the publishers for the December, 1939, Annals. Of the above cash receipts for dues, $1,529.43 is for 1940 and other dues paid in advance.

Permanent Fund

RECEIPTS

Balance in Savings Account, December 17, 1938	$3,008.78
Interest on Savings Account, December 17, 1938, to December 20, 1939	45.39
Interest on Liberty Bond 45554-D	1.43
From four Life Memberships	200.00
Total	$3,255.60

EXPENDITURES

(None)

Balance in Savings Account, December 20, 1939	$3,255.60
One Liberty Bond, 45554-D	50.00
Balance in Permanent Fund	$3,305.60

RESOURCES

Liberty Bond 45554-D	$ 50.00
Balance in Savings Account	3,255.60
Balance in Checking Account	2,048.21
Total	$5,353.81

Respectfully submitted,

CLARENCE E. MICKEL, *Treasurer.*

On motion the Treasurer's Report was accepted, subject to the approval of the Auditing Committee.

REPORT OF THE MANAGING EDITOR OF THE ANNALS

With the increase of one dollar per year in the price of individual dues and the same increase in single subscriptions the Editorial Board has found it possible to publish eight hundred pages of material in the 1939 volume of the Annals of this Society. If any change in the nature of the Annals has appeared it is a tendency toward more physiological articles, some of which could well be sent by their authors to other scientific serials, and in an increase in the number of book notices.

The past year appears to have brought out a greater number of volumes of interest to entomologists than have appeared in any recent year, but the Annals also is constantly gaining in recognition as a review journal for the profession.

It has been difficult for the Managing Editor and equally so for the Assistant Editor to judge the attitude of the readers of the Annals to the development of the feature of book notices. We feel that there are two good reasons for its development: (1) that it is certainly educational in a high degree, and (2) that it is a feature which makes for popularity of the Annals as more members find in each issue book notice items which they take time to read. We have considerable assurance that the Annals is being actually thumbed through and parts more widely read than ever before.

We wish to thank the printers, Spahr and Glenn, for the remarkably clean proof furnished and for their constant expert advice in keeping the format up to high standards. We wish to express thanks to our very efficient secretary, Mrs. Helen S. Lanman, who has had her work increased due to the many banking difficulties in foreign exchange and in discounts and banking charges since the war upset such.

The financial summary follows:

RECEIPTS

Non-member subscriptions	$ 972.73
Sale of back numbers	121.78
From authors for cuts	597.27
Bank balance from 1938	72.67
	$1,764.45

EXPENDITURES

To engravers	$ 530.74
Office help	300.00
Postage	125.75
Miscellaneous	102.07
To Secretary-Treasurer	600.00
Bank balance	74.09
Undeposited checks	14.00
Check cleared through another account through error	17.80
	$1,764.45

Respectfully submitted,

CLARENCE H. KENNEDY, *Managing Editor.*

On motion, the report was accepted subject to the approval of the Auditing Committee.

REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION

RECEIPTS

Balance on hand, December 15, 1938	$221.35
1938 Sales of Volume II (1 copy)	5.00
1939 Sales of Volume I (1 copy)	3.00
1939 Sales of Volume II (2 copies)	9.00
1939 Sales of Volume III (3 copies)	11.20
Interest on Savings Account, July 1, 1938, to December 31, 1938	1.78
Total Receipts	$251.33

EXPENDITURES

Commission to C. C. Thomas for sale of 4 volumes	$ 2.00
Postage on books	.18
Miscellaneous postage	.60
Total Expenditures	$ 2.78
Balance in Purdue State Bank, December 26, 1939	$248.55

Respectfully submitted,

J. J. DAVIS, *Treasurer.*

On motion the report was accepted subject to the approval of the Auditing Committee.

REPORT OF THE AUDITING COMMITTEE

We, the undersigned members of the Auditing Committee, beg to report that we have carefully examined the accounts of the Treasurer of the Society, the Managing Editor of the ANNALS and the Treasurer of the Thomas Say Foundation for the year 1939, and have found them to be correct and properly balanced.

Respectfully submitted,

HAROLD H. SHEPARD, *Chairman,*
M. C. TANQUARY,
HOWARD O. DEAY,
RAYMOND C. OSBURN.

On motion the report was accepted.

REPORT OF THE NOMINATING COMMITTEE

Your Committee places in nomination the following Fellows of the Entomological Society of America, to fill the designated vacancies for the year 1940:

President—W. D. FUNKHOUSER.
First Vice-President—J. A. G. REHN.
Second Vice-President—ROBERT MATHESON.
Secretary-Treasurer—CLARENCE E. MICKEL.
Two Members of the Executive Committee to Serve until 1942—A. C. KINSEY and WILLIAM P. HAYES.
Councilors to the American Association for the Advancement of Science—C. T. BRUES and S. E. FLANDERS.

Respectfully submitted,

A. L. MELANDER, *Chairman,*
E. O. ESSIG,
A. F. SATTERTHWAIT.

On motion the report was accepted and the Secretary instructed to cast a ballot for the election of the persons nominated. This being done, they were duly elected.

REPORT OF THE COMMITTEE FOR THE PROMOTION OF OFFICIAL ENTOMOLOGY

In past years the activities of this committee have been devoted primarily to assisting in securing adequate funds for the operation of the federal Bureau of Entomology and Plant Quarantine. During the past year there has been no need for such assistance.

The question has been raised regarding the problem of public patents for devices used as insect controls, and especially when such a device, chemical or otherwise, has not been developed to a point where it can be definitely recommended to the public. Unless a public patent is concerned with a matter of such importance to the life of the commonwealth as to render its employment a matter of strong necessity, it may operate as a bar to the development of the very thing which it was intended to promote, because it has no monopolistic features. In other words, no industrial concern is likely to feel that it can afford to spend money on its practical development, because whatever it learns about the manufacture and handling of the public patent-covered proposition is available to any other manufacturer.

We are referring to this problem because it has been called to our attention by several of our members who thought it was a situation to be considered by this committee. We have conferred with officials of the federal Bureau of Entomology and Plant Quarantine and learn that they are vitally interested, are making a thorough study of the problem, and expect to be able to offer a possible solution, or at least suggestions, a year hence.

Respectfully submitted,

J. J. DAVIS, *Chairman*,
G. A. DEAN,
T. J. HEADLEE.

On motion, the report was accepted.

REPORT OF THE COMMITTEE ON RESOLUTIONS

1. WHEREAS, the Arrangements for the thirty-fourth annual meeting of the Entomological Society of America have been so satisfactory,

Therefore, be it Resolved, That the Entomological Society of America extend its thanks and grateful appreciation to the local committee on arrangements consisting of: NEIL F. HOWARD, *Chairman*, and MESSRS. D. M. DELONG, F. M. CAMPBELL, T. H. PARKS, J. S. HOUSER, ALVAH PETERSON, R. A. FULTON, J. N. KNULL and HAROLD WATERS, and to the HOTEL DESHLER-WALLICK, and

Furthermore, be it Resolved, That the Society extend to DR. A. AVINOFF its thanks for his interesting and thought provoking address.

2. WHEREAS, the continued growth and success of our society is the subject of favorable comment,

Therefore, be it Resolved, That the society extend to the officers, in particular the Secretary-Treasurer, DR. C. E. MICKEL, its grateful appreciation of their untiring efforts.

3. WHEREAS, the high editorial quality and make-up of the Annals have been continued,

Therefore, be it Resolved, That the society extend to DR. C. H. KENNEDY, Managing Editor, and the Editorial Board its thanks and pledge its unfailing support to them,

4. WHEREAS, the joint symposium on "Fifty Years of Entomological Progress" has brought together much information not heretofore readily available,

Therefore, be it Resolved, That the officers of the Entomological Society of America be instructed to confer with the officers of the American Association of Economic Entomologists with a view of arranging for its publication, if possible.

5. WHEREAS, the continued illness of DR. E. D. BALL has necessitated his entomological inactivity and absence from this meeting,

Therefore, be it Resolved, That the secretary be instructed to send him greetings from the society and best wishes for his speedy recovery.

6. WHEREAS, the death of MRS. HERBERT OSBORN has brought grief to one of our beloved members, as well as to her large acquaintance in this group,

Therefore, be it Resolved, That the Society express its sympathy to PROFESSOR OSBORN and his family.

7. WHEREAS, the society has been grieved to learn of the death of MRS. P. B. LAWSON,

Therefore, be it Resolved, That the secretary be directed to send a note of sympathy to PROFESSOR LAWSON.

8. WHEREAS, the Society regrets the loss through death of the following members during the past year: C. N. AINSLIE, W. E. BRITTON, R. N. CHAPMAN, L. O. ELLISOR, CHARLES R. ELY, H. C. FALL, and H. F. WILLARD,

Therefore, be it Resolved, That the Society extend its sympathy to the relatives and friends, and that this Resolution be spread upon the minutes of this meeting and that the secretary be directed to send a note of sympathy to the families of the deceased.

Respectfully submitted,

Z. P. METCALF, *Chairman,*
ANNETTE F. BRAUN,
ROGER C. SMITH.

On motion, the report was adopted as read.

REPORT OF JOINT COMMITTEE ON BIOLOGICAL ABSTRACTS

Your Committee on Biological Abstracts has the following to report: The sections on Systematics and Economic Entomology seem quite unsatisfactory and an unnecessary duplication of services that are better performed by previously existing agencies. We recommend the discontinuance of those sections unless they seem necessary for persons not engaged in Entomology.

There is considerable opposition to the high price of the Abstracts and disapproval of the breaking up of the Abstracts into sections.

There is considerable sentiment in our committee and also in the committee of the Economic Entomologists for the support of the Abstracts by individual Entomologists because of its value outside of our special fields. There is also the opinion that the more generally biological portions of our entomological publications should be represented in the Abstracts in order to keep the non-entomologists in touch with our work.

For these reasons the committee does not feel that the Entomological Societies should take any group action at this time against the Abstracts, nor contribute Society support, but it does urge individual members to co-operate with the Abstracts.

Respectfully submitted,

A. C. KINSEY, *Chairman,*
W. A. RILEY,
C. H. RICHARDSON,
ALVAH PETERSON,
H. B. HUNGERFORD,
J. S. HOUSER,
C. L. FLUKE.

On motion, the report was adopted as read.

Following the transaction of the above business, the meeting adjourned.

The following exhibits were on display in rooms near the meeting place of the Society:

1. Photographs of Entomologists. HERBERT OSBORN, Ohio State University, Columbus, Ohio.
2. A New Text and Reference Book, "The Chemistry and Toxicology of Insecticides." HAROLD H. SHEPARD, University of Minnesota, St. Paul, Minnesota.
3. Bionomics of Entomophagous Insects—II (a new book). W. V. BALDUF, University of Illinois, Urbana, Illinois.

4. Some Lepidopterous Leaf-Miners of Forest Trees: Larval Work and Imagos. ANNETTE F. BRAUN, University of Cincinnati, Cincinnati, Ohio.
5. Some Common Species of Ohio Orthoptera. EDWARD S. THOMAS, Ohio State Museum, Columbus, Ohio.
6. Entomogenous Fungi. ALVAH PETERSON, Ohio State University, Columbus, Ohio.
7. Circulating Insect Collections Prepared by Ohio State Museum for Ohio Public Schools. EDWARD S. THOMAS, Ohio State Museum, Columbus, Ohio.
8. Diphenylamine for Screwworm Control, and Equipment Used in Micromethods in Entomology.
9. Genitalia Mounts for Small Insects. MILTON W. SANDERSON, University of Arkansas, Fayetteville, Arkansas.
10. A Student's Portable Insect-Pinning and Microscopic Slide-Making Kit. J. R. HICKMAN and THOMAS G. DARLING, Michigan State Normal College, Ypsilanti, Michigan.
11. Improved Type of Riker Insect Mount. RALPH H. SMITH, University of California at Los Angeles, Los Angeles, California.
12. Some Devices Used in Connection with the Iowa Insect Survey. H. E. JAQUES, Iowa Wesleyan College, Mt. Pleasant, Iowa.

Respectfully submitted,

CLARENCE E. MICKEL, *Secretary.*

PERSONAL BIBLIOGRAPHIES

Under this head we will be glad to list personal bibliographies of members of this society. They must be in some printed form such as mimeograph, lithoprint, photolith, planograph or some similar process or actually printed. They must be available from the author on request.

We believe a development of this type of bibliographic service can be of considerable value. Our copies of personal bibliographies sent for notice in the *Annals* are deposited in the Ohio State University Library, Botany and Zoology Division. We list:

List of entomological writings of E. Gorton Linsley, Dept. of Entomology and Parasitology, University of California, Berkeley, Calif. 1930–1939. Mimeograph.

List of the writings of D. M. DeLong, Dept. of Zoology and Entomology, Ohio State University, Columbus, Ohio. 1916–1940. Mimeograph.

BOOK NOTICES

CONSERVATION IN THE UNITED STATES by Members of the Faculty of Cornell University. A. F. GUSTAFSON, H. RIES, C. H. GUISE, W. J. HAMILTON, JR. Pages xi and 445, 232 figs. 9¾ x 6½ inches. Published by COMSTOCK PUBLISHING COMPANY, INC., Cornell Heights, Ithaca, New York. Price $3.00.

Cornell University, founded by a railroad executive, since its beginning has been one of the institutions which has led in the training of engineers and other scientists who have explored and exploited the natural resources of the United States. To speak more generously, Cornell faculty and alumni have been leaders in the development of our country. Through this leadership Cornell has always been well informed on the resources of the Americas. With these reserves in various fields rapidly dwindling, leadership is again shown in the effort, even if belated, to conserve what yet remains. Professor Gustafson is an expert on soils, Ries in geology, Guise in forest management and Hamilton in zoology.

The volume opens with an eighteen-page introduction by Gustafson which is a statement of the limited nature of natural resources (and all resources are, of course, natural) and a brief history of the recognition of the problem by such far-sighted leaders as Theodore Roosevelt who set aside our present national forests, and Charles R. Van Hise, President of the University of Wisconsin whose book, "The Conservation of the Natural Resources in the United States" has been for nearly thirty years the most important source of conservation information. With these is associated our present President, Franklin D. Roosevelt, who has advanced conservation in many directions by furnishing both funds and manpower. However, as the introduction points out, the book itself deals with "Tomorrow's Problems of Conservation."

Part I (pp. 19-160) by Professor Gustafson is a series of chapters on soils and water: Chapter I. Soil; II. Uses and Conservation of Water; III. Soil Depletion and Erosion; and IV. Soil Conservation. Part II (pp. 161-260) by Professor C. H. Guise comprises Chapter V. Forest Resources; VI. Forest Utilization and Depletion; VII. Forest Conservation; VIII. Parks; IX. Western Grazing Lands. Part III (pp. 261-348) by Professor W. J. Hamilton, Jr. includes Chapter X. Fish and Fisheries; XI. Game and Fur Resouces; XII. Conservation of Other Useful Wildlife. Part IV (pp. 349-426) by Professor H. Ries covers minerals: Chapter XIII. Mineral Resources; XIV. The Metals; XV. Coal; XVI. Petroleum and Natural Gas; XVII. The Non-Metallic Minerals.

This volume is a concise, scientific but non-technical review of the problem. It is very readable and as well illustrated as any recently published volume one can select. By this we mean that the photographs chosen are brilliant and exactly to the point under discussion. So few books are really well illustrated even at times when an abundance of such is supplied that we wish to point out this excellence of the present volume.

Each chapter ends with a page of review questions which is the only indication that it has been planned for a possible use as a text-book.

We recommend "Conservation in the United States" to all entomologists (except those immured for a life time behind desks: it would only irritate such) because entomologists in general have an occupation which contacts, almost more than does that of any other group of scientists, those who are responsible for our soils, forests and small game. Every entomologist should have clearly in mind the problems of conservation and the regional solutions of such problems that he can present himself to the farmer, the forester and such as a sympathetic and intelligent person. This is one of the volumes we have reviewed in recent months that has left us with a feeling that the authors are giving the reader merely the cream of the subject. (It is not one of those works where the lone author has strained his intellectual ability in trying to complete chapters ten to twenty within the time limit set by the publisher.) It is a very worthwhile book.

—C. H. K.

HANDBOOK OF PHYTOPATHOGENIC VIRUSES by FRANCIS O. HOLMES. Pages vii and 221, 1939. Published by the Burgess Publishing Company, Minneapolis, Minn. Price, planograph, $2.00.

This handbook presents a classification of viruses, using the bionomial system of nomenclature. The scientific names used are all new and are accompanied by descriptions of the viruses to which they are intended to apply. Appropriate common names are also given, and other names that have been applied to each virus are listed as synonyms.

A new kingdom is proposed and is called *Vira*. Division I covers the viruses pathogenic in plants. Each family has been given a common name according to the characteristic diseased condition produced in the hosts. These names are as follows: yellows, mosaic, ringspot, Fiji disease, spindle-tuber, leaf-curl, leaf-roll, dwarf-disease, savoying-disease, and spotted-wilt.

Each virus is discussed briefly under the following categories: synonyms, susceptible species, geographical discription, induced disease, transmission, serological relationships, immunological relationships, thermal inactivation, filterability, and representative references to literature.

The bacteriophages, with which the author is less familiar, are treated in a supplement. The second and third supplements consist of lists of susceptible and insusceptible plants, and of viruses not treated in the handbook, respectively. The book is indexed and bound in a patented metal ring binding.

As the author states in the preface "the present attempt at classification will serve the purpose of focusing the attention of investigators on similarities and dissimilarities among the viruses with which they work, and thus stimulate publication of findings that may influence subsequent classification."

This book should prove very useful to plant pathologists and those casually interested in plant diseases caused by viruses.—R. H. D.

GUIDE TO THE STUDY OF THE EVOLUTION OF THE WINGS OF INSECTS by JAMES CHESTER BRADLEY, Second Edition, 1939. Pages 1–60, 25 text figs. and 83 plates of wings. Published by DAW. ILLSTON AND COMPANY, Ithaca, N. Y. For sale by the author, Dept. of Entomology, Cornell University, Ithaca, N. Y. Price (paper bound) $1.25.

The text of this volume is a very condensed and even abbreviated guide for the student who attempts to put the correct Comstock-Needham System names on the veins shown in the seventy unlettered plates at the end of the volume. The theory sounds fine: "The student may spread out on the laboratory table . . . . the plates of insect wings . . . and will find that they lead him from the most primitive of conditions step by step along various lines of modification, until end results are attained, so astonishingly different from the starting point that no one could ever have understood how they came about, or what their homologies were, except in the light of such a comparative study."

Being interested in entomology as a sport rather than as a science, and catching dragonflies is a sport rather than honest scientific fieldwork, we have put off and again put off trying to unravel the historic differences of opinion on dragonfly venation as such differences have been publicized by Needham, Tillyard, Carpenter et alii. At times when our conscience has become sensitive we have planned to assemble all their papers and unravel the problem to the point where we could take sides. Then again our social instincts have warned us to remain ignorant, thus to avoid taking sides in a group of such interesting friends. On receiving this little volume and studying the dragonfly wings as per instructions ("with no help from other works") we thought at first Professor Bradley had clarified our fog on dragonfly venation. Soon, however, we discovered an obscure little vein in the base of the wing of the Coal Age protodonate Megatypus which we could not name. So we are still happy in a fog of MAs, MPs and Cus and hope to retain our friends.

We still believe that Professor Bradley was raised in an area of such high venational pressure (the Cornell laboratories) that he little realizes that Tillyard, Carpenter and others had to have more than the base of the wing of Megatypus to assure themselves of correct Odonate venation. The present writer has always maintained that for the instructor such a book should have a published key

which the teacher could keep hidden under the pile of unanswered letters in his desk, but to which he could refer when too many or too few veins appeared in some student's diagram of an insect wing. It is time that some expert on the subject of venation gave us a new book on the wings of insects.

In the present revision of Bradley's earlier (1931) work for Cornell classes in venation, twenty pages and fifteen figures have been added to the text while the plates for study have been increased in number from sixty-seven to eighty-three. In as far as we have read recent studies of venation the volume is up to date in its ideas of what has occurred in the evolution of insect venation. As yet writers are not in full agreement as to how terms should be applied to veins in the posterior half of the wing. We approve of the Cornell system of teaching wing venation to students but we still advocate an up-to-date volume on the subject for the teacher.—C. H. K.

FOURTH SUPPLEMENT TO THE LENG CATALOGUE OF COLEOPTERA OF AMERICA, NORTH OF MEXICO, by RICHARD E. BLACKWELDER. Pages 1–146, 1939. For sale by JOHN D. SHERMAN, JR., 132 Primrose Ave., Mount Vernon, N. Y., price $6.00.

All Coleopterists will welcome the excellent fourth supplement of the Leng Catalogue which includes all references from 1933 to 1938 inclusive to American forms occurring north of Mexico.

The supplement contains a list of the species described during the five year period, also synonyms, changes of names and corrections. Each species listed has a reference to the original description and any corrections are explained in footnotes. The author has omitted species numbers used in the previous lists.

The publication also contains necrology and bibliography during the five year period. A third supplement to Catalogue of North American Coleoptera described as fossils from 1933 to 1938 inclusive is presented. A complete index is given for the Leng list and all supplements, which facilitates binding them together.

—J. N. K.

THE BARK AND TIMBER BEETLES OF NORTH AMERICA, NORTH OF MEXICO, by W. J. CHAMBERLIN. Pages vi and 513, 1939. Published by the OREGON STATE COLLEGE COOPERATIVE ASSOCIATION, Corvallis, Oregon. Price, Press Board, $5.50; Cloth, $6.50.

This publication is a valuable addition to the literature of North American Scolytoidea, and represents an enormous amount of work by the author in its compilation. It brings together in one volume all pertinent information on the subject which heretofore has appeared in scattered publications.

The scope of the book may be roughly divided into two parts, i. e., biological and taxonomic.

The biological part covers many phases, the most important being as follows: economic importance, fossil forms, habits, distribution, introduced species, types of larval and adult galleries, seasonal history, inter-relationships with fungi, natural enemies, ecology, biotic potential, environmental resistance, and control measures.

The taxonomic part consists very largely of original descriptions of each species with keys to tribes, families, genera and species. The keys are taken primarily from Blackman and Swaine, with revision where necessary to accommodate recently described species.

There are 321 figures and five plates appearing throughout the book, many of which are to illustrate the characters used in the key separation of genera and species. Most of these figures are excellent reproductions taken from originals in authoritative publications.

Besides the general bibliography at the end of the book consisting of approximately 450 references, there are five others which cover specific subjects, viz. fossil Scolytoidea, blue stain fungi, nematodes and bark beetles, climate and Scolytoidea, and medication as a means of control.

The book should be a handy reference for all entomologists, especially museum workers, teachers, and specialists in the taxonomy of this important group of plant destroyers.—R. H. D.

STUDIES ON THE PHYSIOLOGY, GENETICS AND EVOLUTION OF SOME CLADOCERA by A. M. BANTA, with the collaboration of Thelma R. Wood, L. A. Brown and Lester Ingle. Quarto, pp. x and 285. 170 figs. Published by the CARNEGIE INSTITUTION OF WASHINGTON, D. C. Price paper bound $2.50, cloth bound $3.00).

Professor Banta, a student from Professor Carl H. Eigenmann's laboratory at Indiana University, followed in the line of the Eigenmann research in that he was added to the Carnegie Institution's Station for Experimental Evolution with the problem set for him of studying the origin and evolution of cave animals. He was provided with a high grade concrete cave, then suddenly the study of evolution went around an intellectual corner.

Jennings and his students were rearing long pure lines of Protozoa and proving that there was an evolution by some other means than by the saltations advocated by the De Vries school. Banta was already breeding cave crustacea and studying their variation as compared with such in surface forms when Morgan's criticism of Jennings' work appeared (1916) in which Morgan pointed out that variation in Protozoa was complicated in that somatic and germinal variation were bound up in the same single cell. Banta saw an opportunity. He applied the bottle, laboratory technique of the Jennings school of protozoologists to the normally parthenogenetic entomostraca. He used Cladocera that are parthenogenetic metazoans in which the somatic characters are distinguished from the germ cell behavior, and that is a group in which sexual reproduction may occur at intervals.

The present volume is a general report on about twenty-five years of study by Banta and his assistants on the evolution of Cladocera. Lines of descent have been followed in great detail up to as many as 1000 generations. Hundreds of lines in several species have been followed. He found that in these parthenogenetic lines some clones mutate while other clones appear to mutate, if at all, at very long intervals. While on this work students of genetics found that the biometric school advocating evolution by minute increments and the mutation school advocating evolution by mutational jumps were both correct. The heritable minute increments were also mutations. Banta's work brought this out very clearly. Banta was unable to clear up positively the cause of the appearance of males at long intervals, usually under adverse conditions. The production of males appeared to be associated with a lower level of food and to accumulated wastes in the water. In his study of sex-intergrades in some Daphnia lines he found that the expression of sex was partially controlled by environmental conditions.

We have cited this volume because we face the same broad problems in the insects, another arthropod group where parthenogenesis crops up in various orders. Banta's work is probably the most detailed study of parthenogenesis ever accomplished. It is on a group in the same phylum of animals as are the insects, hence we can infer that the same phenomenon in the two groups would have many similarities.—C. H. K.

OUTLINE OF DISEASES OF CEREAL AND FORAGE CROP PLANTS OF THE NORTHERN PART OF THE UNITED STATES, by JAMES G. DICKINSON. Pages VII and 259, 8¼x10½ inches, loose leaf, wire back. 1939. Published by BURGESS PUBLISHING COMPANY, Minneapolis, Minn. Price, $3.00.

As the name implies this publication presents in outline form the diseases of cereal and forage crop plants of the Northern United States.

The host plants included are barley, corn, oats, rye, sorghum and millet, wheat, flax, alfalfa, the clovers, and soybeans. The diseases under each host plant are arranged in the following order: Non-parasitic, Virus, Bacterial, Phycomycetous, Ascomycetous, Hyphomycetous (Fungi Imperfecti) and Basidiomycetous. Each disease is briefly discussed in the following manner: hosts, geographical distribution, economic importance, description, pathological histology, causal organisms, life history, control measures and references to the most important literature.

A complete table of contents appears at the beginning of the book, and a list of bacteria and fungi parasitic on the field crops arranged under order and families with common hosts is given at the end. Following this list is the index.

A very usable compilation and a valuable contribution to the workers in plant pathology, and to entomologists interested in diseases transmitted by insects.

—R. H. D.

THE BRITISH MOSQUITOES by J. F. MARSHALL. Pages xi and 341, 172 text figs. and 20 pls. Size 7x10¼ inches, 1938. Printed by Order of The Trustees of the British Musuem. For sale at THE BRITISH MUSEUM, Cromwell Road, London, S. W. 7 and THE OXFORD UNIVERSITY PRESS, 114 Fifth Ave., New York City. Price, cloth bound, one Pound.

In 1920 the Museum issued a volume, A Handbook of British Mosquitoes by W. D. Land. Because of the intensive study since that day the present work by Marshall is practically a new book. From the Preface by Mr. N. D Riley, Keeper of Entomology: "Mr. Marshall's particular interest in these insects dates from about 1920 when, owing to their great prevalence in the neighborhood of his home on Hayling Island, he organized a control scheme which took shape in 1921. The success of this scheme inspired him to build and equip at Hayling Island the now well-known British Mosquito Control Institute, which has been ever since a centre for both pure and applied research upon mosquitoes, and is in addition an admirable educational institution." Hayling Island is on the Channel coast just east of Southampton.

The number of known British mosquitoes is now twenty-nine. The twelve chapter headings are as follows: I. How to recognize a mosquito; II. Classification and naming; III. Life history; IV. Stages of Development; V. How to distinguish the genus in each stage of development; VI. How to distinguish the species and larval instars; VII. The British anopheline mosquitoes; VIII. The British culicine mosquitoes; IX. Mosquito "control" in Britain; X. Some general notes relating to the biology of mosquitoes; XI. Bibliography; XII. Index.

This is a readable book, even anatomical discussions are easily understood because of the close interweaving of text and illustration. And the drawings! They are by Mr. A. J. E. Terzi, an artist with a flawless line. How we envy him his ability to draw beautiful sweeping curves. His illustrations of anatomy are perfect line drawings. The chapters on control and on biology of mosquitoes are interesting reading. The last severe epidemic of malaria occurred in 1859. Since 1870 signs of the gradual disappearance of malaria in Britain are already noticeable.

The printing and binding are excellent. We recommend The British Mosquitoes as a model volume to all authors planning monographic publications.

—C. H. K.

PHYSIOLOGICAL GROUP DIFFERENTIATION IN LYMNAEA COLUMELLA by JOSHUA L. BAILY, JR., pp. x and 133, 22 text figs., 2 pls. 1939. 9¼x6 inches. Published by the JOHNS HOPKINS PRESS, Baltimore, Md. Price

This volume is No. 14 of the Monographic Series of "The American Journal of Hygiene." Because the economic entomologists have run squarely into the baffling problem of "physiological species" we wish to call the attention of those interested in such problems to "Physiological Group Differentiation in Lymnaea Columella." The work concerns the physiological and morphological differences between two populations of snails of the "same species" from two ponds somewhat over one hundred miles apart. Living material was reared from generation to generation in the laboratory and the mass of data obtained was subjected to various types of biometric study. While entomologists are not interested in water snails they could be interested in the methods used in the study and definition of closely related populations.

The nine chapters are headed: I. Preliminary Survey, which cites previous attempts to define species and subspecific forms in snails; II. The Problem; III. Material; IV. The Method; V. Longevity; VI. Fecundity; VII. Growth; VIII. Interrelations Involving Different Biological Variables; IX. Conclusion.

The author found that snails from the two ponds were noticeably different in longevity, fecundity and in nature and amount of growth. The only other study that parallels this investigation is that of Dobzhansky, 1935, on races of *Drosophila pseudoobscura*. The author points out that he barely more than opened up the questions involved. What is the composition of *columella* populations in all the ponds in which it is found east of the great plains? How are these populations related to each other? We recommend the volume as another, but well planned, attemnt to define "species."—C. H. K.

CANADIAN AND OTHER POEMS, by FRANCIS CECIL WHITEHOUSE, pp. 1–122, 1934. Published by the RYERSON PRESS, Toronto.

To Mr. Wm. F. Schick, the skilled compositor who puts the finishing touches on ANNALS editorial technique we dedicate this notice. Mr. Schick's days are filled with the worry of the unobtrusive crowding of ten pages of printed matter onto nine pages of paper, of leaving no white unfilled with print or illustration. His nights are nightmares of travelling across endless plains of standing type and sudden falls into bottomless open spaces that should not exist. This is just one more book notice for a vacant page just discovered at the end of the March issue which is already on the press.

For many years we have carried on a correspondence with the Canadian entomologist, Mr. Whitehouse, who introduced odonatists first to the dragonflies of the prairie provinces and later to those of British Columbia. Mr. Whitehouse, a writer by trade, enjoys dragonflies because of their grace on the wing and the sheer sport of outwitting them in their capture. In this volume of delightful descriptive poetry he has given his friends a poet's view of the world in which all of us live, but out of which we too often cull the sordid rather than garner the beautiful. Dare we quote an entomologist in the ANNALS?

From "Winter":

> The dreary, whitened prairie mile on mile.
> The mighty pall of death's o'erspreading woe.
> O! gone, the sweets of Mother Nature's smile—
> 'Neath panoply of snow.

Or from "The Salamander's Song":

> Oh! for the dim and distant past
> When toothless reptiles flew;
> And serpents-of-the-sea patrolled
> The bayou's waters blue,
> Or sought the caverns of the deep
> And slept, and fought, and slew.

Or from his "Dedication À Toi":

> So small a thing I ask—the hum of bees,
> The wayward melody of brook and trees,
> The azure blue.
> To me the fragrant violet never dies;
> Shadows are dreams through which my spirit flies
> To you.

We hope Mr. Schick is content until the June issue.—C. H. K.